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ABSTRACT

As an outgrowth of "A Study of Exemplary Mathematics Programs," conducted at the Northeast Regional Exchange in Chelmsford, Massachusetts, a panel of experts rated 150 school mathematics programs that had submitted evidence of excellence in student outcomes, for example, high test scores, exceptional course enrollments, significant awards, notable successes for female and minority students, and special success with mathematical enrichment programs. A panel of experts then visited 28 of these schools, singly or in pairs, to find evidence for the factors and the conditions predicated to be associated with excellence in precollege mathematics, namely: (1) a high valuation of mathematics achievement effectively communicated to students; (2) an emphasis on frequent homework with extensive feedback; (3) a flexible curriculum geared to maximize individual student success; (4) a curriculum developed and owned by the staff; (5) a school climate consistently favorable to high expectations; (6) a classroom environment supportive of student hypotheses and conjectures; (7) efficient and productive use of class time by both students and teachers; (8) considerable commitment to extra time for instruction and preparation by teachers; (9) exemplary programs characterized by lack of non-instructional distractions; and (10) an overriding professional atmosphere that stimulates participation. From the 28 schools visited, 10 school mathematics programs were selected for inclusion in this document because each of them exemplified at least 1 of the 10 success factors proposed. Effective leadership appears often in these stories, as do careful decisions about the curriculum and its implementation, but the most important theme involves the growth of teachers and the development of their teaching. Also included is an annotated bibliography, and a list of recommendations from this study. (JJK)

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STORIES OF EXCELLENCE

Ten Case Studies
from

A Study of Exemplary Mathematics Programs

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U.S. DEPARTMENT OF EDUCATION
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INTRODUCTION

Excellence has been a popular topic for writers in this country, especially when it concerns success with business and money. The most prominent recent example is the Peters and Waterman book, In Search of Excellence -- a collection of stories about companies that have learned how to outshine their competitors. In it, readers are taken through some of the crucial planning and decisions that made these companies the dominating forces that they are.

When they are done carefully and have a fair amount of narrative as well as analysis, stories of excellence can help readers to construct, out of their own personal knowledge, images of influential factors. They rarely point to universal rules for success, but the opportunity they provide to stand in other people's shoes for a brief while can lead readers to a kind of tacit understanding of excellence.

Lately, stories of excellence have been appearing about education -- for example, The Good High School by Sara Lawrence Lightfoot and the series of reports called The Search for Excellence in Science Education by the National Science Teachers Association. They have provided a glimmer of hope in an educational climate that is often gloomy, where the current tone has been set by the spate of national reports on school problems. Undoubtedly, those reports have been an inevitable reaction to the American educational crisis, but they will be effective only if they are complemented by accounts of how some school people are excelling in the face of the crisis. The ten case studies in this volume are an attempt to expand this understanding. They are an outgrowth of A Study of Exemplary Mathematics Programs, conducted by my colleagues and me several years ago at the Northeast Regional Exchange in Chelmsford, Massachusetts. The study was funded by the National Institute of Education to "uncover factors and conditions associated with excellence in precollege mathematics," and it spanned the period from December 1982 to February 1985. The particular details of the study can be found in our final report, available from the Department of Education. In brief, we convened a panel of experts to rate about 150 school programs that had submitted evidence of excellence in student outcomes -- e.g., high test scores, exceptional course enrollments, awards, notable success with females and minorities, special success with extracurricular mathematics, and so on. We chose 28 from the highest rated programs to visit and study in depth. They were spread across 16 states and the District of Columbia and they included exemplars in all the categories of excellence in student outcomes.

Seven colleagues and I visited these programs singly and in pairs. As director, I visited 17 of the 28 and the case studies in this volume describe 10 of those 17. Among them are 1 elementary school, 1 junior high school, and 8 high schools, a mix that represents roughly the proportions in our original pool. They range from a small rural high school with a student body of 190 to several large urban high schools, and from schools that are no strangers to mathematics success to schools that have only recently become successful. Programs that succeed with general mathematics students are included, as are programs tailored for talented students. Most importantly, each of the factors deemed important to the success we studied in the 28 programs is represented in at least one of the ten case studies.

A list of the factors we deemed important appears later in this book, but I will leave details about those factors to a reading of our final report. More important for this introduction are the several overriding themes that emerged from the list of factors. Effective leadership appears often in these stories, as do careful decisions about the curriculum and its implementation, but the most important theme of all involves the teachers and their teaching. For example, we witnessed a high degree of cohesiveness, collegiality, and sharing among the mathematics staffs we visited -- not in all programs, to be sure, but in most -- and, to our eyes, the resulting community efforts produced consistently high expectations, good instruction, and excellent student outcomes. A middle-school principal in West Virginia referred proudly to his mathematics teachers as "interlocking, mutually supportive, and diversely unique people," and the characterization fit the majority of the programs we visited.

It is impossible to overstress the value of teacher collegiality to the quality of a mathematics program. Teaching mathematics is a profoundly human affair and, as such, should be steeped in human interaction. However, for a variety of reasons -- e.g., tight teaching schedules, an undervaluing of collegiality by unions and administrators, a self-protective but self-destructive tendency of teachers toward isolation -- cohesive staffs are the exception in American schools. No more poignant statement of this came our way than that of a Michigan elementary school teacher who addressed the excellence of her program this way: "This is the fifth school I've been in in this district, and it's the first one in which the teachers share." Her meaning of sharing was comprehensive: ideas, materials, tests, magazine articles -- anything that can lend cohesiveness to a group effort to make a program excel. Because of her comment, and because of numerous similar comments, we came away from our study convinced that cohesiveness and sharing, along with leadership that makes it possible for them to flourish, form a solid foundation on which to build an exemplary mathematics program. To say that this happened in all the schools we visited would be an exaggeration, but the case studies reveal how often and in what varied ways we found the substance for our conviction.

Why is collegiality so influential? For one thing, it makes the quest for excellence more visible because teachers keep talking about it; for another, it lends consistency to the quest because teachers are constantly comparing notes. And students, like all learners, respond well to consistency. In fact, it was noteworthy how the students in several programs used the word "always" to characterize what they thought was superior about their programs, as in "I can always get help if I need it," or "The mathematics teachers here are always organized." Another reason collegiality seems important is that teachers who talk together regularly can plan for excellence. For instance, they can give strength to their commitment not to let students fail or lose interest in mathematics. One striking example is the staff of the school called Trinity High School in its case study, where the mathematics department head spoke of the teachers' commitment not to "let general mathematics become the terminal course it is in so many schools."Quite often, this staff unity takes root under the guidance of a visionary leader, a department head or principal who encourages it and sets up mechanisms to make it happen. Generally, these leaders see their mathematics teachers as the professionals they are, and encourage their professionalism by delegating authority and by showing active respect for their opinions. The case studies of the high schools called Silver Valley, Greeley, and Taylor portray three manifestations of this kind of leadership.

More often than not, the effective mathematics leaders are staunch champions of their staffs within the school district hierarchies, and get them what they need to be effective and to grow professionally. If teachers bring life to the programs we visited, it is often the leaders who bring life to the teachers.

Teaching styles varied among the teachers we observed in these exemplary programs, but there were themes that cut across the variety. For instance, consistently minimizing risks and maximizing trust were almost universal patterns in the scores of classrooms we visited. It was not uncommon for us to hear students in class make comments like:

> "That's where I made my mistake."
> "I don't think I have that down yet. I got too many wrong on the homework."
> "Could you go over that again?"

Another theme relates to climate. I visited more than a hundred classrooms in this study, and was deeply impressed by the respect and dignity that reigned in the vast majority, while scorn and sarcasm were scarcely evident. Combine these qualities with the sense the students had that they could "always get help," and you have some powerful lures for students to persist in mathematics. One of my colleagues in the study characterized this student-centered approach to teaching by noting the difference between teaching mathematics to kids and teaching kids mathematics. In the latter type of teaching, mathematical content is inseparable from the attitudes, expectations, and feelings that students bring to their learning.

I have not said much about the social and environmental backgrounds of the exemplary programs which, of course, begs a question that is critical to our study: How much of what we learned from these programs is transportable to other schools? After all, several of them are in special, even privileged, surroundings. Even so, I believe that the central factors in the success of these programs are eminently transportable. In particular, their teachers work hard at keeping students in the center of their professional gaze and they work equally hard at communicating with each other. These factors are transportable. For their part, the leaders work hard to provide the freedom, encouragement, and support that will allow the teachers to succeed in those efforts. That, too, is transportable. In fact, the most important message to be conveyed by our study is that most of the teacher and leadership factors that impressed us can appear in any school setting. To be sure, teaching in a well-heeled district or serving talented students can help to improve results but, as the case studies show, the really effective behaviors of the teachers and leaders we visited have little to do with environmental circumstances. They are learned behaviors that have been thoughtfully and deliberately integrated by the individuals who use them so effectively.

My colleagues in this study and I were deeply impressed by the essential role teacher expectations and behavior played in the success of the exemplary programs. In highlighting the central importance of the teacher, our study

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Page 3 continued

and these case studies are doing nothing that has not been done many times before. But the message never seems to sink in as much as it should with those who run school districts or train teachers, so one more attempt to make the point may help. We can only hope that the conditions under which teachers are allowed to flourish, conditions such as those described in these ten stories, will become the goal of all those who desire to make their mathematics programs exemplary.

Note. The names of schools, locations, and people in these case studies are fictitious. This is a traditional practice in case study writing, and it is consistent with the National Institute of Education's careful insistence that the process they were supporting was a research study and not a contest -- in other words, that the 28 exemplary programs we visited were not necessarily the 28 top programs in the country. It seemed to me, however, that these stories of excellence needed the inclusion of real names in order to be most useful for readers. I proposed to leave the body of each story intact, but to name the school and location (but not people) in the paragraph that precedes each story, provided that the school people had consented. Six of the ten programs consented, and the names of those sites are provided.

ACKNOWLEDGMENTS

One of the greatest blessings for me in the two years of A Study of Exemplary Mathematics Programs was the opportunity to work with and learn from the people who were part of the project.

I have observed and been affiliated with several educational task groups in the past decade. Never have I witnessed as much energy, intensity of effort, and effectiveness as I witnessed in the work of our Expert Panel, who met twice during the project -- in the first year to rate the 146 programs on the basis of student outcomes; in the second year to provide ratings for the presence of the hypothesized factors in the programs that were studied. Because of their careful work, we were assured from the start that we had 28 exemplary programs to visit, and I am grateful. The members of the Panel were Marty Badoian, Peter Castro, Mary Grace Kantowski, Ferd Prevost, Bob Reys, and Sheila Rosenblum.

I am also grateful to the seven Field Researchers who joined me in the site visits. They too worked very hard, and they brought a variety of skills and backgrounds from which I learned much. Jere Confrey brought her sharpened classroom observation skills and keen sensitivity to equity issues; Bob Kenney and Steve Leinwand, as state mathematics coordinators, brought their wealth of knowledge about what is typical in school situations; Sue Martin and Kay Tobin brought, from their teaching, textbook, and school union backgrounds, their finely honed instincts about what makes school programs and districts tick; Larry Vaughan brought his deep knowledge of school research and his seasoned ability to see patterns in a variety of phenomena; and Elsa Martz brought her infectious enthusiasm and unquestioned ability to discern the degree to which children's needs are being met in school situations. I learned from all of these Field Researchers, and they share largely in the study's success.

I am grateful to Lynn Griesemer, Bob Herriott, and Larry Vaughan at NEREX for their constructive criticism, suggestions, and guidance in the research design of the project, and to Gloria Gilmer and Kent Viehoever at NIE for the same. Support staff Joan King, Sharyn Sullivan, and Ann Cadogan helped the mechanical aspects of the project to proceed smoothly.

Finally, I am deeply grateful and indebted to Elsa Martz, Project Associate, for her abiding enthusiasm, continuing encouragement, and friendship throughout the project. She was a superb model of energy and effectiveness throughout the two years.

Mark Driscoll

DAWSON ELEMENTARY SCHOOL

The mathematics program in Dawson Elementary School is distinguished by a liveliness that extends beyond the classroom walls. Students participate in activities such as math club and a math newsletter; teachers share materials and ideas; the principal communicates clearly his commitment to a central role for nontraditional mathematical problem solving. The school uses the Comprehensive School Mathematics Program, and teachers have adapted and supplemented where they have seen fit. The result is a curriculum where all students get at least 55 minutes of solid mathematics each day. Staff collegiality, at least in the sense of sharing, is exceptionally strong. Leadership from the district level is strong and supportive, and complements the principal's leadership at the school level.

Dawson Elementary School is Lawton Elementary School in Ann Arbor, Michigan.

DAWSON ELEMENTARY SCHOOL

> "The teachers here have high standards. No one is marking time. It is also the first school I've been in where the teachers share with each other."
>
> Dawson teacher, a veteran of four other schools in the district.

> "Dawson never does anything on a minimal basis."
>
> Parent of a Dawson student.

Most elementary school mathematics programs are cut from the same mold. Textbooks do vary and, occasionally, so do the sequences in which topics are covered, but the general character of what students experience in the classroom stays the same from school to school. Dawson Elementary School is a refreshing exception to this norm. Its teachers and administrators have experimented with new classroom experiences and have created an excellent and lively program in the process.

Before students finish the sixth and final grade at Dawson, they have been immersed in mathematical problem-solving, been exposed in more than a passing way to logic and mathematical applications, and been challenged repeatedly to take responsibility for their mathematical learning. Several factors converge to make all of this possible. The curriculum -- partly prepackaged and partly homegrown -- invites enthusiastic participation by the students; furthermore, the people behind the program are outstanding in their thoughtful dedication. The teachers reflect deeply and broadly about mathematical learning and they work exceptionally hard to make their vision come to life; the administration shares their vision and supports them in it.

Dawson is a K-6 school located in the residential section of a small city (population circa 105,000), the home of a large Midwestern state university. The year we visited, the school population numbered 365 students and 13 teachers. Because it serves as the school for children of the university's foreign graduate students, Dawson had about 50 children from 25 different countries.

We were attracted to Dawson because of its test results, the involvement of students and staff in problem-solving and mathematical applications outside of class, and because of the variety of classroom problem-solving and computer activities. In particular, fifth-graders in the year preceding our visit (1982-83) averaged 7.1 on the computation section and 8.2 on the mathematical concepts section of the California Achievement Test. In a district-wide test, sixth-graders at Dawson were at the top in both computation and problem-solving in a comparision with the 25 other elementary schools in the district. Students can take part in a math club, use a microcomputer laboratory before school begins, work on LOGO and BASIC in class, and engage in "Problem of the Week" sessions which stress nontraditional problems. Dawson has taken its mathematics program well beyond the boundaries that typically limit elementary school programs, yet has managed to maintain a successful record in test scores.

Within the past few years, Dawson's school district has adopted the Comprehensive School Mathematics Program (CSMP) as its mathematics curriculum at the K-3 level in all schools. Primarily because of the enthusiasm of the principal and several teachers for the program, Dawson Elementary School has adopted the entire CSMP K-6 curriculum. That move occurred in the 1982-83 school year, and the transition demanded even more time and energy from an already generous staff. In 1983-84, adaptation to the change was complicated by a fairly bitter teacher strike in the district, which delayed the opening of school for three weeks. The dust from the strike had barely settled when we visited in late October.

Two of us spent three days at Dawson Elementary School. It was our first visit to an exemplary elementary school in the study and, as we entered the school for the first time, we were reminded that elementary schools can be a bit more experimental in creating atmospheres than schools for older students. In the school's foyer was a giant display case highlighting several mathematics books and problems from CSMP and from the Oregon Problem Solving Project. It was the only display in the main entryway, and it used some pleasant graphics to challenge viewers to take a crack at the "Problem of the Month," an exercise in uncovering a number theory pattern. The display was derived from a mathematics newsletter which one of the teachers sends throughout the summer to his students, challenging them to solve problems like:

> "What does each set of numbers have in common?
> A. 35, 56, 91, 112, 168, 2247
> B. 59, 68, 77, 95, 86, 1094"

The display was typical of the efforts we observed during our visit to keep mathematics visible and perceived by students and parents as both valuable and entertaining. Many schools stress the value of mathematics but they often work from a limited view of mathematics; Dawson transcends the usual tendency in elementary schools to locate the primary value of mathematics in mastering basic algorithms.

In many communities, the combination of a new and nontraditional curriculum with a divisive teachers' strike could be devastating to school-parent relations. Though not unscathed (several mothers approached the head of the school PTO with angry comments like: "After that strike, don't expect me to be baking any cookies for the school this year..."), Dawson's mathematics staff seems generally to have retained the trust and support of parents. When CSMP was adopted, the district ran a series of meetings for parents to explain the program and to assuage fears about children's losing out on the basics. It was not clear to us how well the communication was working elsewhere in the district, but Dawson appeared able to capitalize on the trust in the staff already established among parents, even though the Dawson task was compounded by their K-6 adoption. A fear about CSMP's coverage of the basics, such as the long-division algorithm and algorithms for manipulating fractions, arose among Dawson parents as it did throughout the district, but those parents we spoke with remarked how willing the teachers were to supplement and to send home tailor-made basics work with children on request. (One parent expressed her trust this way: "We recognize that the Dawson teachers' commitment extends beyond 9 to 4.") And at least some of the parents are reflective enough to see the value of CSMP through the teachers' eyes. To one parent we spoke with the program seemed to be "a way of thinking about why you are doing what you are doing, and why it works."

Several mothers described their confidence in the mathematics program with strikingly similar stories: "My daughter is no whiz in mathematics, yet she's doing all right, and though she might complain about other subjects, she never complains about her math. Also, I see she can apply it in her everyday life -- in measuring and shopping, for instance." The parents we talked with were exceptional, in that they were especially involved in school activities, yet we had no evidence that their good feelings about the program were not shared by others.

Unlike a few of the programs we visited, which thrive almost in spite of their surroundings, Dawson's mathematics program obviously benefits from several environmental factors. For example, the proximity of the state university has its indirect salutary effects through courses taken by Dawson teachers and through the teachers' contact with university faculty. But the outstanding background feature is undoubtedly the tightly joined commitment to excellence, expressed in the open community trust in the teachers' hard work, availability, and cooperation.

While the mathematics program at Dawson thrives in an environment that supports its rare, dual impetus toward success and innovation, that supportive environment hasn't developed on its own. The large and excellent university influences the culture of the city and the values of its residents. And Dawson Elementary School serves families that are primarily middle class and educated. (It does not, however, have the community's wealthiest parents. Several elementary schools are better off on that score.) But such conditions exist in many other American communities as well, and they do not often translate into the enthusiastic and wide-ranging support we observed around Dawson, the kind of support exemplified in a passing remark made to us by the head of the school PTO: "To apply math, you can't stick with the text." Support of that kind is born of trust in the teachers, but it is nurtured through the enthusiasm for the program of the administrators, from the principal to the district office. In a word, leadership contributes significantly to the program's success.

The principal supports the program in several ways. A former district mathematics specialist before he became a principal about fifteen years ago, he is very strong on K-6 articulation. Indeed, despite our focus in the study on grades 4 and above, he insisted we visit a second-grade class to observe how the primary level children are prepared, and he accompanied us there to make sure we enjoyed it as much as he does. He is a strong advocate of CSMP and is enthusiastic about some of the effects he has observed during its implementation. ("It is not uncommon to hear applause coming from CSMP classes.") At the same time, he is proud of the supplementary activities such as the math newsletter, the math club, and the mutual relationship developed between Dawson and a mathematics/science education professor from a college in a neighboring community. There are occasional visits of the professor to do electronics and logic work with the fifth grade, and occasional visits of the fifth-graders to the professor's education classes to model their CSMP classroom activities.

The principal's stamp of leadership is on the program in several ways. He led the way to the K-6 CSMP adoption in Dawson. Partly in coordination with a district move toward subject specialization in the intermediate grades, he has

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moved one fourth-grade teacher (strong point: reading) away from teaching mathematics and one fourth-fifth grade teacher (strong point: mathematics) into teaching only mathematics. Finally, he has shown his trust and confidence in the teachers by minimizing his interference. They are, as we describe later, a very proud and professional group of teachers, and he treats them that way, in particular allowing several of the strong individuals on the staff to be themselves.

If the principal's role has been to allow the innovations to happen, the real impetus to ensure that they do happen has come from the district office, in the persons of the Mathematics Specialist and the Coordinator of Secondary Education, formerly the Mathematics Specialist. Both women are strong advocates of CSMP and have been responsible for its implementation. This has been a complex and challenging task in that it involved first winning over the administration, teachers, and parents, then providing each teacher with the training and support necessary to use the CSMP materials, which demand consistent nondirective questioning in the classroom and hence a special brand of teacher training. One or the other of the women visits each CSMP teacher in the district at least twice a year to extend this training and to smooth the CSMP adoption. (A second-year CSMP teacher at Dawson said she was visited by them once a month.)

Like CSMP, subject specialization has been the occasion for increased teacher training. As the district has moved toward specialization at the intermediate level (during the year of our visit, about 20 percent of the elementary school children in the district were taught mathematics by specialists), the two administrators have designed seven fifteen-hour courses for district teachers. The program, dubbed the "Mathematics Endorsement Program," will be integrated into a requirement for specialization at the intermediate level. Topics for the courses are problem-solving, geometry, probability and statistics, and computers. (All of the district teachers of mathematics in grades four, five, and six have taken the computer course.) Furthermore, through these two administrators, the district encourages teachers to attend professional meetings, providing release time and substitute teachers, as well as some travel and expense money. In short, training and professional development have become essential components in the district's mathematics program.

While she was the Mathematics Specialist, the Coordinator of Secondary Education earned a statewide reputation for her vision and for her effectiveness. She not only engineered the district adoption of CSMP, but cleared the way for teachers in the district to push past the usual limits on elementary school mathematics and to challenge their students to be young mathematicians. Her ambition and pride have been extremely influential in the district's experiment with elementary level mathematics, and she has played a central role in fashioning Dawson as the centerpiece of that experiment.

Like other visionary leaders we met in this study, she is an opportunist and a publicist, eager to aggrandize the efforts of her mathematics teachers. On our arrival at 8:00 a.m. for a second day at Dawson, we were greeted by a reporter for the city newspaper, invited there by the Secondary Coordinator to talk with us and her about the nature of our visit, and to watch the exemplary teachers in action.

Implementation of curriculum was evidently a factor in Dawson's success. The CSMP curriculum is distinctive in its nontraditional approach to teaching mathematics. Concepts are developed through the use of three visual "languages": the language of strings (Venn diagrams used to develop number concepts and a facility with sets), the language of arrows (a functional approach to operations), and the CSMP "minicomputer" (a pictorial abacus used to develop place value and other concepts). Probability, statistics, and transformational geometry also are threaded into this spiral curriculum, which places a heavy stress on mental arithmetic, pattern-finding, and analytical thinking.

Because it is so nontraditional, the curriculum could intimidate teachers and alienate parents. As noted above, however, the Dawson parents appear to trust the wisdom and commitment of their principal and teachers and, partly through the CSMP orientation sessions provided by the district, also appear to have developed their own cautious enthusiasm for the program.

For their part, the staff were well geared for CSMP when it came along. Three of the veterans had already established their own nontraditional approaches to teaching mathematics -- incorporating logic, programming, and mathematical applications such as electricity and banking into their content, along with some special attention to the student interactions that ensue when such mathematics is encountered. And, once the CSMP curriculum was adopted, none of the teachers allowed themselves to become tied to it totally. We saw a fourth-grade teacher, new to CSMP and in her second year at Dawson, who spiced a CSMP lesson with her own improvised "Facts of Five" drill. She interrupted the drill several times to ask the class what patterns they saw in the growing table of multiples of five, and the children enthusiastically bounced up and down as they recognized and pointed out patterns. When we commented to her how exciting it was for us to sit through such an innovative drill, she observed: "I couldn't have done that before CSMP. Did you see how well they do mental arithmetic and even handle negative numbers? That's CSMP."

Her attitude is typical of the staff: make use of CSMP, but don't abandon supplements deemed important. We saw a teacher of the fourth and fifth grades using activities drawn from the Oregon Problem Solving Project and Creative Publications, from the LOGO programming language, and from application activities developed by the professor from the nearby college. Two other teachers have developed their own banking and merchandising activities for the sixth grade. The widespread willingness to complement CSMP with other valuable activities gave much of the life to the vibrant program we observed at Dawson Elementary School.

Given the teachers' zeal, it is easy to miss another strong point in the program, one that is tied directly to the CSMP adoption. The individual lessons and the sequencing of lessons are such that a consistently full 55 minutes of mathematics are required every day. Coupled with the existence of a separate "Problem of the Week" session run for twenty or so students by the teacher who handles the fifth grade and half of the fourth grade, this means that Dawson students do a healthy amount of mathematics.

The introduction to CSMP, however, apparently was rough for several teachers, for several reasons. They felt that the time spent with them in training was inadequate, especially with regard to supplementing. As we described above, the job of supplementing CSMP is proceeding smoothly enough, but it has cost the teachers in terms of time and strain. One teacher told us how she had realized during the administering of an assessment test, to her grief, that her students were unfamiliar with the long-division algorithm, so she called a halt to the test-taking long enough to give them a brief lesson on the algorithm. Another teacher, though a strong CSMP advocate, described himself as "buried in work" due to his supplementing. The CSMP program has obviously engendered a mixed reaction from the teachers. By dint of its focus on open-ended and critical thinking, it invites creative supplementing by the teachers, and they seemed to welcome that. On the other hand, some of them evidently chafed when they found themselves expending energy to fill in gaps in the program that they refused to gloss over. Dawson is in a curriculum quandary that will not disappear quickly, but it is testimony to the dedication of the teachers that excellence has continued unabated.

The mathematics teachers at Dawson devote themselves to their craft in ways that seemed classic by the time we completed our site visits to exemplary programs. Like their counterparts elsewhere, they use time superbly, go to pains to minimize failure and to maximize expectations for success for their students, and maintain a staunchly professional posture that leads them to look for ways to renew themselves as teachers.

In the seven mathematics classes we observed, we saw precious little time wasted. The non-mathematical items that were dealt with were dispatched quickly. ("I know you have Halloween candy from your Trick or Treating last night. I don't want to see or hear it"). Furthermore, every teacher used a variety of questions and used them frequently. ("Can someone give me some other names for 3/4?"; "How did you get that?"; "Is 56 a multiple of 10?"; "Who can give me a number less than -10?"). Even the fourth-grade "Facts of Five" drill was elevated from the mundane task it usually is to a dynamic give-and-take through the teacher's questions and her stress on patterns.

Ironically, the strong pedagogical skills of the staff have grown from what one sixth-grade teacher described to us as two different educational philosophies. In his opinion (and in ours, too, on the basis of our brief visit), the fourth and fifth-grade teachers built their style around the mathematics and mathematical problem-solving strategies derived from CSMP, LOGO, the Oregon Problem Solving materials, and so on, while he and the other sixth-grade teacher placed a heavy emphasis on the role of "affective education in cognitive learning." They come by their focus on affective learning naturally: one is a former clinical social worker, the other a former staff member of a hospital for emotional disorders. One result of their emphasis on affect is open attention in the classroom to the issue of student responsibility, as in the following comments and questions we noted in one class:

> "I see the same hands up. Some people aren't working."
>
> "How many of you are uncertain whether this is a review?"
>
> "These are the kinds of side issues about fractions which you need to consider."

The second sixth-grade teacher, on leave during the year of our visit to develop computer materials for the district, gave her own assessment of the philosophical underpinnings: "We are very success-oriented. We want the kids to feel successful." She described for us their efforts to "take the challenge posed by students coming into the sixth-grade with their preconceptions about who is good and who is not," in particular, seizing opportunities to highlight the good test results of those who are seen as low on the totem pole.

The sixth-grade teachers also have employed an imaginative technique they call "the 100 percent clue." If a student turns in a paper containing a mistake, one or the other of the teachers says something like, "You have one mistake; I'll give you 3 1/2 minutes in which to find it, correct it, and earn 100%." "Sooner or later," they told us, "that student is turning in a 100% paper." The teacher on leave went on to tell us: "We try to assess student needs every six weeks or so, and make changes accordingly. We will ask in class, 'Who wants a review?', then split the students up between us. One of us will take the review students, the other will take the rest for a day or more of enrichment. We trade the review and enrichment groups occasionally and, when we do that, we renew ourselves as teachers."

This conscious effort to take care of themselves while they take care of their students is typical of the professional posture and cooperative attitude of the Dawson teachers. Theirs is not a unified sense of collegiality, as it is in many of the programs we visited. The two different "philosophies" -- one based on mathematical problem solving, the other on emotional growth -- legislate against total unity. Yet there are sharing and cooperation, nonetheless. The fourth-grade "Facts of Five" teacher, who is in her second year at Dawson and who has taught in four other schools in the district, proudly told us how teaching magazines are circulated around the staff, and that they are read and discussed. She remarked how freely materials, ideas, and ditto sheets are shared among staff members, a significant change, she said, from the jealousy she experienced in other schools. Nor did this strong professional stance stop with the mathematics people. A fourth-grade teacher who teaches no mathematics is a former language arts specialist and program planner for a professional reading organization.

The staff commitment to professionalism had one manifestation we found especially touching. Because he has become convinced of the value of LOGO, the fifth-grade mathematics teacher purchased two Texas Instruments microcomputers and the LOGO software with his own money and placed them in his classroom. (The school had available a lab with six Commodore Pets, under the librarian's supervision, for use before and after school.)

Despite the sharing of ideas and materials among teachers, the communication patterns looked in need of honing. The sixth-grade teachers felt very independent and self-reliant in the implementation of their affective educational goals; the fifth-grade mathematics teacher was intently focused on his use of CSMP and his supplementary computational, problem-solving, and LOGO activities. There was, however, little talking across the two grade levels. Consequently, two "educational philosophies" that needn't be in conflict were left to appear that way. The rift was not great and did not threaten the program, but we were left wishing it weren't there and wishing that the principal would take a hand in improving the staff communication.

Despite the lack of coordination between the two "philosophies," Dawson students seem to thrive through the double challenge. Before they reach the sixth grade, mathematics classes are full of mathematical challenges. During our visit, for example, the fifth-grade teacher challenged them with materials on the logic of and/or gates, using a calculator as a model, and on set concepts from the rather sophisticated Elements of Mathematics Program from CEMREL. His high expectations and enthusiasm for such activities have been contagious enough so that a handful of students now subscribe to the magazine, Oregon Mathematics Teacher, and maintain a watchful lookout for good problems.

In the sixth grade, the mathematical challenge stays alive for the students, but it takes on a flavor of self-knowledge. Classroom interactions now guide them toward recognizing the extent of their responsibility in learning mathematics -- when to ask for review, how to eliminate carelessness, and so on. Although the staff and program would benefit from weaving the two approaches together, the situation suffices to give the Dawson students far more than is the lot of their peers in other schools.

The trend toward subject specialization has brought several new tensions to the Dawson program. In the year of our visit, only one of the teachers specialized in mathematics; he taught mathematics to all of the fifth-graders, as well as half of the fourth-graders. But two fifth-grade teachers taught no mathematics at all, and the school was unable to go after a replacement for the sixth-grade teacher on sabbatical because, as is the case every year, the final number of students was not settled until the foreign graduate students moved to the state university in late August.

Consequently, we saw mathematics classes as large as 42 and 45 students (as well as a few in the low 20s). The teachers of the large classes we observed did a remarkable job of keeping students on task, of maintaining a continuous flow of work, and of involving students with open-ended, as well as single-answer, questions. Even so, in each of the two largest classes we visited, we estimated there were at least 20 students who gave no indication during the hour whether they understood or were totally confused. Furthermore, a few occasional student comments, indicating either misunderstandings or good insights, were ignored. The return the following year of a second sixth-grade teacher promised to mitigate some of the problems of class size, but neither the principal nor the teachers expressed concern when asked about the effects of size. Such is the confidence in their teaching skills, yet we thought their lack of concern short-sighted.

Nor did the specialization sit well with those who no longer teach mathematics. One of them remarked that she missed the flexibility allowed in the self-contained classroom, the freedom to expand or contract the amount of time devoted to a particular subject depending on need. She also remarked that she missed teaching mathematics, though her shaky and frustrating introduction to CSMP, with what she saw as inadequate training and several materials foul-ups, had convinced her to step aside.

So, all was not smooth in the Dawson mathematics program. With the CSMP adoption and the trend toward subject specialization in the district, together with the stress brought on by that year's strike, the program's flow had run into a few rough spots. Yet there appeared to be no real threat to the program: the talent, energy, and integrity of the teachers are too strong, as are the support and trust all around them. Their challenge is not to survive, but to fashion their experiments with CSMP, with specialization, and with supplementary activities into a program that is even more exemplary than the one we visited.

Summary

In The Good High School, Sarah Lightfoot makes the point that conscious change is a hallmark of good schools. In order to improve, a school must choose its goals, choose its methods, and attend carefully to both. Like the other programs we visited in our study, Dawson Elementary School exemplifies such conscious change, yet in its ambition and innovation, it far exceeds the standards for conscious change set by most good mathematics programs.

The teachers who make the program thrive are webbed in support from all sides -- from the nearby college and university with their intellectual support, from the parents with their trust, from the principal with his pride and moral support, and especially from the two district administrators with their respect, encouragement, and material support.

Without any doubt, however, the strengths of Dawson's mathematics program flow primarily from the strengths of the teachers -- their hard work, their reflectiveness and expansive thinking, their high expectations for themselves and their students. They have an image of themselves that is far grander and more professional than is typical for elementary school mathematics teachers. And they picture the young people they teach as much more than mere repositories of information; to them, they are young explorers who can be challenged to their limits in both mathematics and self-knowledge.

* * *

SAMPSON MIDDLE SCHOOL

Sampson Middle School (grades 7 and 8) is distinguished by a mathematics program in which nationally standardized test scores have vaulted from the mediocre to the excellent in the past decade. It is also distinguished by the wide variety of staff who have influenced the swift improvement of the program. The superintendent was the catalyst and has been the overall architect; the principal has infused the school with a serious yet supportive tone and high expectations; the guidance staff have been careful monitors of student placement and of parent communication; and the teachers have been active participants in the redesign of the curriculum while, in the classroom, they maintain an effective blend of support and high expectations. Recently, the school has looked beyond test scores as the only measure of excellence and has put together a mathematics team that competes effectively with the best teams in the state.

Sampson Middle School is Franklin Middle School in Nutley, New Jersey.

SAMPSON MIDDLE SCHOOL

> "We believed in the idea that what was wrong with much of public education was the failure of responsible people to make tough judgments."
> Superintendent, Sampson Public Schools

The tough judgments in Sampson were made by the school board and the superintendent, but when it came time for action, they brought in participants from every group that had decried Sampson's educational mediocrity. Teachers and administrators were enlisted to transform the curriculum, and citizens with a penchant for tutoring or for running supplementary programs were invited to become part of the new order. The editor of the local newspaper became an active ally, as well as monitor, in the process of change, and through his efforts public interest swelled and support was sustained at the polls. The results have been phenomenal. In seven years, the system, and the middle school's mathematics program in particular, were propelled from mediocrity to excellence.

Two of us spent two days at Sampson Middle School in the Fall of 1983. We observed classes, interviewed all of the seven mathematics teachers, a few of their students, the superintendent, the principal, the assistant principal, the two school guidance counselors, the district coordinator of gifted education, and the town's newpaper editor. The picture of Sampson's success described by all of these individuals was consistent and it was simple: a fully cooperative effort to design and carry out changes mandated by the school board at the superintendent's request, has led to a deep sense of ownership of the program on the part of teachers and other staff, and high expectations for success among the whole community, including students.

Sampson (population 35,000) is a suburb of a large Northeastern metropolis and contains an even mix of blue-collar middle class residents and white-collar middle to upper middle class residents. It is a slight anomaly among communities along the Bo-Wash Corridor, in that it is a very stable community ("People live and die in Sampson," we were told by one of the school's guidance counselors), with two-thirds of its population married couples with children, and fully 80 percent of the high school's graduating seniors the year we visited composed of students who attended kindergarten in Sampson. There are some blacks, Asians, and Hispanics in the town, but Sampson is predominantly white and has a large and well-established Italian-American community.

Sampson Middle School comprises grades seven and eight, and is the only junior high school in the town, taking students from five public and two parochial elementary schools. During 1982-83 there were 635 students and 48 fulltime teachers in the school, with 7 teachers specializing in mathematics. The school has a distinctly safe and orderly aspect, enhanced by the building's age and grace. It was built in 1927 and retains that substantial look and feel of buildings from that era, sporting carefully maintained WPA murals in its spacious auditorium, large new windows throughout, and hallways which are immaculate and very, very, quiet. It is an environment that invites visitors; parent groups and civic groups reportedly use the auditorium frequently. It is also an environment that encourages serious and businesslike attitudes in students and teachers. As one mathematics teacher who has taught in other schools told us, "It is a joy to teach in a school where students know they are expected to work."

The Sampson community attends to its schools as much and as carefully as any of the communities we visited. Its concern as well as its stability are reflected in the nine-member school board, whose members tend to stay in office for two terms or more. The president, during the year of our visit, had been on the Board for 10 years; the man who had been president until 1981 was on the Board for 29 years. More important than members' longevity, perhaps, is their rejection of the aloofness that so often defines school boards' relationships with schools, exemplified by their invitation to students who score 100 on the district mastery test to each June's board meeting for recognition and praise. The newspaper editor, Tom Larsen, provided some special insight into the Board's interest and commitment. He has covered every school board meeting in the town for years and can contrast what he has witnessed there with what he knows is the norm in board meetings in similar towns. "Other school boards are likely to take up entire meetings arguing about who let whose brother get the plumbing contract in a particular school, or something similar. In Sampson, the meetings are almost always focused on education. Just last week I went to a meeting where they were discussing the possible adoption of a new science textbook. It appeared to me that every board member had read the book!" Larsen provided another insight into the background of the school program we were studying. In a state where political corruption is not rare, Sampson has not had an incident of corruption in the municipal government in over 50 years.

School support flows from the community in other ways besides the school board's attention, some invisible, others visible and serving to perpetuate the aura of excellence. A cadre of 35 senior citizens present one quiet, if not invisible, line of support with their tutoring program in the elementary schools. Larsen provides a more visible means of support through his newspaper, a vehicle that he has used as a staunch supporter of the schools (and especially of the superintendent) in their recent rise to excellence. One editorial and two front-page articles hailing our visit appeared in the days during and after our visit, and the second article announced that the paper would sponsor a "Pride Day Banquet" for the seven mathematics teachers at the school. Coupled with the announcement was a picture of the teachers. Since our visit and mostly in response to it, an Academic Boosters Club has been formed in the town, composed of prominent citizens who want to highlight excellence in their schools. In post-visit communications with me, the superintendent proudly proclaimed, "We are probably the only town in the state with an Academic Boosters Club."

In a way, the state's governmental structure has made it possible for the entire town to show its support. Every municipality in the state votes on its school budget, and in Sampson that has meant deciding on how important class size is and how valued individual teachers are. The principal of Sampson Middle School, Anthony Parente, acknowledged the astounding support of the community and Board when he told us: "In my seven years, I haven't had to 'rif' any mathematics teachers, even though the school has shrunk from 810 students to 635 students." As a result, mathematics class size in Sampson Middle School averages around 20 students, a luxury everyone seems committed to defend.

As in all the communities we visited, we concerned ourselves with the intensity of parent involvement in the Sampson mathematics program, wondering how strong a factor it might be in the excellence of the program. Parents do involve themselves in the Sampson Middle School mathematics program, but the intensity of the involvement seems proportional to the level of the students: the lower a student is tracked, teachers told us, the less responsive are his or her parents to progress reports and other feelers sent home.

The news seemed only a slight bit of tarnish on an exhilarating picture of community support, yet the support, like the rise to excellence, has been a recent phenomenon in Sampson. Seven years before our visit, the town was forced by its new superintendent to look at its relatively low standing in test scores, in both local and state comparisons, and the concern and shame that was generated led to calls for change and, in the superintendent's words, "tough judgments." Of particular concern were the following statistics: sixth-grade students were testing at about the 67th percentile in the state basic skills test in mathematics; seventh graders were testing at the 41st percentile in total mathematics in the Iowa Test of Basic Skills (ITBS); and eighth graders were testing at the 39th percentile in ITBS total mathematics. At that point, the current superintendent was given the fiat to make changes, and changes began to take place.

Seven years later, the transformation was amazing. Sixth graders tested at the 99th percentile in the state basic skills test and the seventh and eighth graders tested, respectively, at the 99th and 97th percentiles in ITBS total mathematics. (Note: While this case study was prepared, the 1984 ITBS scores arrived, and both seventh and eighth graders scored at the 99th percentile.) Also, while 25 students took eighth-grade algebra in 1978, the number has now climbed to 69. To the district's administrators, this is one of the indicators of their success. Furthermore, in the words of Principal Parente, in his application for selection in our study: "In addition to testing, ninth-grade course selections are another indicator. The last two years have seen an increase in the number of eligible eighth-grade algebra I students who select accelerated algebra in grade nine (an increase from one-third to one-half), and this year, the first year of prealgebra in grade eight, almost all prealgebra students have enrolled in ninth-grade algebra I." During the same period, the numbers of students in the lowest, remedial track were reduced by half, important testimony to the universal nature of the rise to excellence.

At Sampson, as at every site we visited, we looked for the stamps of leaders -- behaviors and decisions that have had an annealing, nurturing, or guiding effect on those who have made the mathematics program as good as it is. Given the evident and carefully planned nature of Sampson's rise to excellence, the groundswell rising from the "tough judgments" at the top of the administration, it was clear to us that leadership would be a prevalent theme in our interviews and observations. Though the primary decisions were made at the top, others in the district have shown the force and influence on the program of their own behavior and decisions. Parente, the principal, maintains a low profile in the school, and yet it was clear to us that the comfort and safety in the school environment and the very businesslike expectations, were the direct results of his firm control. Parente has also assumed the role of a middle-level officer -- a captain or major -- in the superintendent's campaign for excellence, participating with his teachers in Saturday planning sessions, even though administrators, until recently, were unpaid for those efforts.

At another level of leadership, the two guidance counselors in the middle school have taken steps to ease the burden on the mathematics teachers. They meticulously nurture the articulation of the mathematics program with the elementary schools, and they are assiduous in defining a role for themselves as a buffer between parents and teachers. (Every concerned or complaining parent is routed through the guidance office before talking with teachers.) In so doing, they have earned the deep trust and gratitude of the staff.

The mathematics chairman, who is a lawyer and also the union representative in the school when we visited, helped to lead the district teachers in a spirited, though relatively rancor-free, struggle for a 19 percent raise and "the best contract in the county" several years ago. He received no additional pay as chairman, and his leadership was not as pronounced as at some other schools we visited, though his presence seemed solid and his influence real.

Of course, the preeminent leader behind the rise to excellence of Sampson's mathematics program has been the superintendent, Martin Langone. When he began his tenure, he decided to focus the district's attention on changes in the K-8 mathematics curriculum, and to fashion those changes after a "top-down philosophy" -- that is, the belief that a concentrated effort to improve expectations and achievement among top-level students would eventually filter down and improve expectations and achievement among all students. At this point a decision was made that Langone, Parente, and the teachers all agreed was crucial to the Sampson turnaround. Offered $40,000 by the school board either to hire a curriculum coordinator for the district or to find a workable way to use existing personnel to revamp the curriculum, Langone chose the latter. In so doing, he set two pillars for support of the excellent mathematics program that emerged several years later: he began the building of a committed team and he gave them a clearly defined goal -- to revise the curriculum, piece by piece, so that test scores would rise. "I showed the teachers the test scores from some of the surrounding districts -- all higher than our scores -- and they got fired up to make the necessary changes."

To capitalize on their eagerness to improve the scores, he commissioned a committee of K-6 teachers to meet on Saturday mornings to recommend mathematics curriculum and textbook changes. Various texts were scrutinized and textbook sales people were invited in to make presentations; when the candidates were reduced to four, every district teacher tried out all four. A poll led to the final choices. Next, the district paid teachers from grades one through eight $15 an hour to meet on ten Saturdays to revise the curriculum and to develop tests that reflected those changes in the curriculum. Parente met along with his mathematics teachers, and the tests they put together were deliberately designed to be tougher than the state skills test. According to Parente: "When the staff had a chance to make the tests easier, they chose not to." To add fiber to the resolve emerging in the district, the superintendent mandated district-wide policy of a minimum of one-half hour of homework a night.

The mathematics program at Sampson Middle School has five levels. The top level comprises students who have been identified as especially talented at the end of grade four and who then take part, in grades five and six, in a Saturday enrichment program called the Cultivating Academic Talent Program, a program whose first teacher, sleeves rolled up and acting like the former mathematics teacher he is, was the superintendent. ("I wanted to show the teachers that these talented kids could handle more sophisticated topics like algebra.") At the lowest level, the school and the district were trying to show that their commitment to improvement was universal. During the year of our visit, there were 4 teachers and 1 supplemental teacher for 57 students and, as we noted above, the numbers of students at this level were diminishing from one year to the next.

Is the "top-down" approach working? All of the people we talked with were convinced it is working very well. They pointed to the halving of the number of students in the bottom mathematics level. They also pointed to the fact that the third level of the eighth grade was using the textbook that had belonged to the second level until the previous year. A seventh-grade teacher told us that her incoming students seemed better prepared in computation, so she had the luxury of doing more geometry with them. The department chairman, who was teaching the top-level eighth-grade (algebra) class, acknowledged that the kinds of word problems being covered by the teacher of the top-level seventh grade (prealgebra) were not very different from what he customarily used with his group. Thus, he said he would have to look for ways to supplement and enrich his algebra curriculum, because the students coming through the program were better prepared. "Also," he added, there is no way that we could have devoted two weeks to computer literacy several years ago," referring to the new decision to give every seventh grader a two-week computer literacy mini-course as part of the regular mathematics courses.

Articulation of the curriculum across grade levels has been a natural outgrowth of the planned improvement in Sampson. The cooperative across-grades spirit begun by Langone in the Saturday meetings has been continued by Parente, the principal, who involves high school department heads in the middle school curriculum development -- again on Saturday mornings. Despite her primary focus at the fifth and sixth-grade levels, the district coordinator for the gifted has conducted two-week training programs with all of the middle school teachers to prepare them for teaching gifted students. The two middle school guidance counselors consult with every sixth-grade teacher in the district, discussing test results with them and listening to their recommendations for placement. Furthermore, as the guidance counselors pointed out to us, the improved record of success at the elementary level (test scores have been rising there, as well), along with the four-year-old homework mandate throughout the district, has instilled a set of higher expectations in incoming seventh graders.

The guidance counselors seemed an especially important part of the maintenance of success at Sampson Middle School, more important than their counterparts at any other school we visited. At the beginning of each year both guidance people sit down with teachers and talk about incoming students -- what to expect from the group of incoming seventh graders, which students have family problems, which students have special needs, and so on. Both are veterans, former teachers who have been working in Sampson district schools for at least a dozen years, and they belie the popular image of guidance counselors as feckless and bored; they obviously enjoy their work and enjoy working together. Indeed, each talked of drawing inspiration from the other. They are strong advocates of the teachers and, whenever then can, they act as buffers and interlocutors between parents and teachers. ("The average amount of time we spend each day talking with parents is greater than the average time we spend talking with students.") Mathematics is a primary focus for them: "We spend more time on mathematics than on other subject areas because the students are so homogeneously grouped in the five levels, and so are more difficult to place." The attention to mathematics apparently has spread beyond course placement, as the two counselors indicated they seek out the mathematics people for lunchtime company. It was clear that they are appreciated by the mathematics teachers, one of whom said she doesn't hesitate to go to them for help, describing them as "very efficient in calling parents and backing us up."

The mathematics curriculum in Sampson Middle School is typical of most schools in its dependence on textbooks. The lowest level is somewhat exceptional in that the students we observed used worksheets in their classroom work. Another exception is the two-week computer literacy subcourses each seventh grader takes, using the four Apples and the handful of terminals owned by the school. Unfortunately, however, we saw very little in the way of enriching content in the mathematics courses, even at the top level. Perhaps it is a result of the intense focus on test-score improvement, and in that case, understandable, but we were saddened to watch such motivated students carefully toeing the line of textbook learning. Apparently, however, the opportunities for enrichment are growing, as the department chairman indicated to us in his portrayal of the improved mathematical background of his incoming eighth-grade algebra students. Other teachers remarked on their increased confidence in introducing algebraic concepts to middle-level students. If the superintendent, the principal, and the teachers follow through completely on their commitment to the "top-down philosophy," they will let the spirit of the Saturday program for gifted fifth and sixth graders filter through the five middle school levels of mathematics. During 1983, the Saturday program was taught to 48 students by a local resident who taught at a nearby university and who introduced innovative topics on Saturdays in a "risk-free environment." The same opportunity ought to be available to all students.

Extracurricular mathematical activity has been modest at Sampson Middle School. About 20 students ("the whizzes," as one teacher described them) constituted an after-school club that did fairly well in county competitions. But, at the time of our visit, Parente and his staff were eyeing a more active role for the school in mathematics competitions and, indeed, we were informed several months after our visit that a Sampson Middle School team had made its way to the state finals in the Math Counts competition. Principal Parente, who passed on the information to us, was delighted with this new arena in which to strive for excellence.

Clearly, tough decisions, careful planning, and strict adherence to goals have propelled Sampson's mathematics program upward. Another very important factor has been the quality of the mathematics staff at Sampson Middle School. About half of them were certified K-8 and the others were certified 7-12; two have taught in high school. As one of the teachers pointed out to us, this balance of perspective adds strength to the department. There is another facet of the department, however, which seemed especially important to the success of the mathematics program. Not only did the teachers make good use of class time, reviewing homework and engaging students in mathematical activity from start to finish in each class period we observed, but they also were consistently among the most empathic teachers we observed, in our site visits. The quote that best capsulized the empathy for us was spoken by a third-year teacher at Sampson, a candidate for a master's degree in computer science, who apparently thrives on her teaching of the lower level students: "I know what it's like to be freaked by tests." We watched her, with arm around their shoulders, cajoling these students, especially the girls, to sit down and introduce themselves to the very basics of computer use.

Another teacher, who was teaching the lowest level of all, and who managed in a lesson on metric measurements to engage a group of eighth graders in a fairly active discussion, impressed us with his respectful and supportive behavior with the students. He told us, "There are days driving to work when I find the prospect of reaching this lowest level class pretty gloomy, but then I picture my own children. I treat these kids as I would want my own kids to be treated." In the class we observed, he was true to his ideal, reviewing homework exercises with the ten students in the class, moving about enthusiastically, appealing to a chart of conversions on the blackboard, prodding with hints ("What's 3/10 of 100?"), all the while making it clear that he would not deviate from his standards ("Stay with us, Ben."). In the last part of the class he told the students to try a set of conversions on their own. We were impressed with the diligence all ten students showed in attempting the exercise, again with how he moved about, helping those who were stuck, but we were even more impressed when he asked, "How many got them all right?" and only one girl raised her hand. No disappointment crossed his face; no disapproval entered his voice. Their effort obviously sustained him and he showed them respect; they, in turn, repaid him with their trust and honesty. In other teachers' classes, we could infer the consistency of their respectful and empathic behavior by the willingness of the students to pipe up with comments like, "That's where I made my mistake," and "I don't know how to set up this equation." It was clear to us, after our visits to all the teachers' classrooms, that they have set up a consistently risk-free environment for mathematics students at Sampson Middle School. They make clear their expectations that the students will try, and when they do, they are rewarded with respect and approval.

Although we were impressed with the lack of wasted class time in mathematics and very impressed with teachers' empathy and their respectful and supportive tone in the classroom, the teaching strategies we observed were generally rather uninspired. Questioning usually consisted of one-word answers and there was little engagement of students in discussions about their mathematical understanding. More typical were questions that mirrored the flow of textbook prescriptions, such as: "Chris, why did you label the car first?" . . . (Chris) "Because it had the least information." Testbook prescriptions are not harmful in themselves, but they can be wasteful and misleading when they totally replace questions that probe students' thinking. Consequently, we were left wondering how much students really understood of what transpired in the classes we observed, and we were left wishing that the staff at Sampson Middle School didn't rely on tests as much as they do for their gauge of student understanding. They and others in the community have asked the question, "What is excellence?", have answered it, pursued it, and achieved it. Now it seems time for them to broaden their answer.

Summary

On the whole, a multitude of positive factors far outweighed the drawbacks of the mathematics program at Sampson Middle School. The superintendent has taken a stable and supportive community, a bright and committed staff, and a seemingly universal willingness among school people to engage in cooperative improvement, and parlayed it into a successful program in which almost everyone can feel some ownership. It has been a solid accomplishment. As one of the newpaper editorials, addressing education in Sampson, put it in its headline: "Tradition of Excellence Going to Stay."

* * *

DEER RUN HIGH SCHOOL

Deer Run High School is a small rural high school that has built an exemplary mathematics program around a winning mathematics team and the high expectations spawned by the team's success. Careful nurturing of the program by a pair of successive school principals and the dedicated work of the school's mathematics teacher have increased considerably the number of students who go on to take mathematics in college and have raised the whole community's awareness of the importance of mathematics.

DEER RUN HIGH SCHOOL

> "Results follow perceptions. The way to improve a program is to change people's perceptions about it first. Then good results will follow."
> Former principal, Deer Run High School

> "Mary works very, very hard for the program. American education is heavily subsidized by underpaid women like her."
> Present principal, Deer Run High School

By standards set at many urban and suburban schools, Deer Run's small, rural high school mathematics program might not be considered exemplary at all. Relatively few courses are offered and, while test scores are good, they do not shine very brightly when taken out of context. Context was important in our study, however, along with absolute standards for excellence; we sought out programs that far exceed expectations for success in their particular settings and with their particular students, as well as programs that would meet anyone's criteria for success.

By this flexible standard, Deer Run was a welcome addition to our study, an exemplar of an important yet fragile commodity in this country -- successful mathematics programs at tiny rural high schools. Like the small farms that surround them, these programs usually have meager financial resources, and they struggle. With the spreading teacher shortages in mathematics, their struggle has become especially acute: often, the well-being and even survival of a program revolves around one person. Should that person leave the program or become ill, the students must do without all but the most basic of mathematics courses until a substitute can be found, someone who has the appropriate background and is willing to work in a small town for light pay. That kind of substitute is getting harder and harder to find.

Deer Run has shown that one way -- perhaps the only way -- out of mediocrity for such programs is a combination of enlightened leadership and dedicated teaching that, together, squeeze the most out of available resources. The leadership found a mechanism -- team competitions -- to convince the school people and even the Deer Run community that there was more potential for success in mathematics than they believed, and the teaching took the bit of newfound success from the competitions and worked it into an expected pattern. Now test scores and course enrollments are up, spurred upward by the general enthusiasm for mathematics competitions.

The drive to overcome mediocrity in Deer Run's mathematics program has by no means been completed. We saw things in the program we did not like -- for example, some of the teaching behavior we observed -- and these cut down on the program's glitter for us. Even so, all of the problems we noted are surmountable, if conditions continue to invite the staff to experiment with improvements. However, the fragility that haunts much of rural education continues to hover over Deer Run's established pattern of success and makes their struggle to sustain their success an especially heroic American educational story.

Deer Run is a small Midwestern town of 1,100 people, set in the middle of corn and soybean fields, which were flattened from harvest when we visited in November of 1983. No building in the town exceeds three stories except for the grain elevator and that, in classic midwest fashion, looms for miles from its perch next to the railroad tracks. The houses along the main street, all freshly painted white in celebration of the town's 150th anniversery, added to the town's special, simple appeal.

Mr. Atkinson, the high school principal, described Deer Run as filled with "a strong Protestant ethic and Dutch blue-eyed conservative families." It is a stable community, as well -- 75 percent of last year's high school graduating class were schooled in Deer Run since kindergarten. Most of the high school's 18 teachers are also from the immediate area. Familiarity and roots evidently have their appeal, but they are about the only attractions that can offset the town's low teacher salaries.

Though Deer Run is small, its school district covers a 62.5 square mile area. During the year of our visit, the high school contained 190 students in grades 9 through 12, most of whom lived on farms in the area. The demands of farm life, coupled with the distances traveled to and from school, understandably cut into students' attachments to school. In addition, the common practice of passing farms from parents to children has traditionally cut into school ties even more, especially as those ties have been linked to postsecondary education. But lately there has been a turnaround in Deer Run. When Sam Walker, Deer Run's former high school principal and superintendent (and now superintendent in a larger, neighboring town), took over the high school 9 years before our visit, only 4 of 45 graduating seniors were going to college. In 1982-83, 18 of 39 chose to continue their education beyond high school.

In a community like Deer Run, which has few college graduates besides its teachers, such a change is revolutionary. In part, as a November 1984 series in the Wall Street Journal made clear, the change can be explained by the social fabric changes in farm communities in the past decade. Farming remains a viable life for fewer and fewer young people, and they are obliged to look to other careers. Even so, an hour's conversation with Sam Walker is enough to convince a visitor that social forces alone have not made the difference in Deer Run. His pursuit of change has been vigorous and intense, and the pursuit has touched mathematics more than any other subject.

The mathematics department had 1.5 teachers: the fulltime person, Mary Vandenburg, was teaching general math, algebra I, algebra II, precalculus, and a double session of computer science (BASIC); the half-time teacher was teaching business math, algebra I, and geometry; a course in Fortran was taught by one of the science teachers. Two aspects of the mathematics program made it particularly attractive for a site visit. First of all, nearly 80 percent of the students were enrolled in at least one mathematics course. Second, in state and local mathematics competitions, the school has fared well, despite the fact that, as Principal Atkinson told us, "In every math, computer, or biology tournament we enter, we're usually the smallest school." Like the increase in college-bound students, these two changes have been relatively recent.

Mathematics competitions have become Deer Run's lever to success primarily because of Walker's zeal and Vanderburg's hard work, but another factor has also helped. The state mathematics teachers' association is one of the most active in the country in organizing competitions on all levels -- local, regional, and statewide -- and they appear to do a remarkable job of publicizing and generating enthusiasm for them. "They get the maximum out of what has to be a meager budget," Walker said. "But it works. People are generally aware of the competitions. Around this area, if you win math competitions, they think you have an excellent program."

Walker mused about the value of perceptions as he sat with us in his office in a nearby town, where he had recently begun as superintendent of schools. It is a larger town than Deer Run, with a more diverse population, a wider range of interests, and more complex problems, yet he is already priming his high school's mathematics team to win. With a mixture of pride and disappointment, born of his old and new ties, he reported that the team had just placed second to Deer Run in a county competition.

He was confident, however, that history would repeat itself, that once again his intuition was correct: if visible improvements occur (in this case, a steady climb in competitions), then he, as leader, could change the school's and community's perceptions of their mathematics program. At that point, he will be able to spring from their changed perceptions into demands for more improvements. "I am more sure than ever," he told us. "Results follow perceptions."

On the scale that Walker experiments with his "Results Follow Perceptions" notion, only small towns would seem to qualify as laboratories. Larger settings carry too many variables, too many people to allow his kind of frontal assault. But we did see the phenomenon at some larger schools, manifested however, in more subtle forms: mathematics staffs who make themselves more visible in their schools and communities than other departments by their extraordinary availability to students, by their exceptional efforts to work with feeder schools to unify programs, as well as by their well-publicized successes in competitions. In various settings, principals and superintendents told us such things as: "They're our stalwarts." "They're my hardest working department." "I try to give them what they ask for. They earn every bit of it." For their parts, the exemplary mathematics programs do ask more, and also demand more of themselves. It is not their nature to rest on laurels, and it is generally not in the nature of their leaders to let them rest on laurels. Walker was principal and superintendent, not department head, but his leadership toward visibility and affecting perceptions has its counterparts in other exemplary programs, usually, in high schools, through department heads.

The program at Deer Run apparently lacked any lustre until seven years before our visit, when Walker had an idea and took some initiative on it. His idea was as simple as it was forceful: first, he would guide the program to some gains; then he would turn the community's favorable impressions of the gains into fodder for further gains. The particular route he chose was through mathematics competitions, because it was relatively inexpensive and because it lent itself to visibility quite readily.

At the beginning, he worked with a teacher at a local junior college to locate as many collections of mathematics contest problems as they could lay their hands on. He then engaged Mary Vandenburg, the fulltime mathematics teacher then relatively new in the school and new to teaching, to work on developing a math team by using the contest problems in her courses. They expected a modest, if not humbling, beginning to their contest results. But Walker told Vandenburg to aim to move up one place per year, on the average, in local and state competitions. After a few years, when that had begun to happen, he went to the school board, improved results in hand, and persuaded them to raise the mathematics requirement at Deer Run High School to two years. In the meantime, he acted, in his own words, "like an athletic coach." He and Vandenburg identified 10 or 15 talented students in each grade of the high school and began to groom them for the team, even asking athletic coaches to release some students early for mathematics competitions.

In 1983-84, 33 of the 190 students were involved in mathematics competitions. In previous years, the number had been as large as 50. Enthusiasm for the competitions is so keen that students who aren't even enrolled in a math course come to Ms. Vandenburg to ask if they can be on the team. The new principal, Mr. Atkinson, a former engineer and mathematics teacher, has been bitten by the contest bug and so continues to support the school's involvement in mathematics competitions. (As we arrived the first day of our visit, he was in the hallway posting the results of the most recent contest, in which Deer Run nosed out Walker's team for first place.)

With Sam Walker gone, and Ms. Vandenburg comfortably settled into the mathematics program after eight years, Atkinson's role in the continued success of the program is somewhat secondary, but his enthusiam and support are important. And he too is getting ambitious. "Pretty regularly, we have a small handful of students who can handle all the mathematics we throw at them. We need something to offer them. I've asked Mary to look into the Elements of Mathematics program for them." This program, called EM for short in the mathematics education community, is a program that has been adopted for use with gifted students in St. Louis County in Missouri, and elsewhere. To us, it seemed a surprisingly ambitious choice, but it fit nonetheless into the fervor for mathematics that has bitten the Deer Run community.

One other note on Atkinson: his wife and home are fifty miles from Deer Run in the suburbs of the nearest major city, where his wife is a school administrator. He rents an apartment near Deer Run during the school week and returns home for weekends. "I left engineering for education in middle age and got involved in a doctoral dissertation on school climate and school improvements. When the job opened in Deer Run, I took it because of the real school improvement that has been going on here." Obviously his interest in the program is no longer clinical, and his chosen life in education, with its hardships and sacrifice, makes a heartwarming story, one that fits nicely into the broader Deer Run picture that unfolded for us.

By the time we visited, the school community and, indeed, the entire Deer Run community, were sharing in the pride and support of the program. The school librarian, a former mathematics major in college, made herself available to students for math tutoring in the library. The woman who until the previous year was the school guidance counselor had a reputation for careful attention to placing students in mathematics. She occasionally used the results from the Differential Aptitude Test to have selected students reverse the usual order and take algebra II before geometry, if they seemed from their test results to be unprepared for geometrical thinking. She also established a reputation for encouraging girls in the middle school and the high school to think beyond nursing and school-teaching as possible careers. (A parent: "My daughter used to think about nursing. Conversations with Jean directed her toward engineering. Now she wants to be an engineer.")

The middle school developed its own math team. Through its carefully designed set of objectives for its mathematics curriculum (really an unofficial mastery learning program) and through its sharing of a teacher on a half-time basis with the high school, the middle school established some continuity with the high school program.

The town is well aware of the math team. When Mary Vandenburg wanted to send an especially talented student to a competition in the East a few years ago, she garnered some financial support from the Lioness Club in Deer Run, additional support from a town merchant, and the rest from school funds. The student was able to go to the competition. (By all accounts, it appears he was an exceptional student and a source of local pride. He is now at MIT, and three or four of the school's teachers avidly shared anecdotes about his experiences at MIT with us over lunch.)

One further anecdote caps the story of the math team in this tiny community. The district's new superintendent told us how, on the evening of the most recent competition, he was roused from supper by automobile horn-blaring and the ringing of his doorbell. "I really didn't know what was going on. When I opened the front door, there were Mary and the team waving and flashing their first-place ribbon."

Not surprisingly, competitions are on Mary Vandenburg's mind as she manages the Deer Run mathematics curriculum and implements it from day to day. (The curriculum is really her responsibility alone -- the half-time teacher from the middle school has little to say about the curriculum.) They are on her mind as she begins teaching algebra I each September: "I look for candidates in that group and I start recruiting." They are also on her mind as she makes herself available to students "before school, after school, during lunch, during breaks, and during my planning periods."

During these times, when she is not providing remedial and general help, she is working with her team members. Occasionally -- as, for example, during our visit -- she will have team members give presentations during class on their contest work. Contest activities are not restricted to the math team. Approximately 80 students a year (more than a third of the school) take the American High School Mathematics Examination (AHSME) of the Mathematics Association of America. A small group are involved in the contests in mathematics and science called Test of Engineering Aptitude in Math and Science (TEAMS). In 1982-83, Deer Run won their district and regional competitions, and then placed fourth at the state level. Typically, they were the smallest school represented at the state level.

The value of mathematics competitions to a school's program -- especially when they are as pervasive as at Deer Run -- is open to debate. We saw a wide range of opinions in our study. One department head we visited told us that he avoided them "because they mainly teach tricks" and are not conducive to a thoughtful approach to mathematics.

Other department heads we visited allow competitions to play but a minimal role in their programs. And, of course, there are the schools we described in case studies like East High School and Trinity High School, where contest victories are considered a valuable measure of success. Their value to Deer Run in this regard is clear, but we happened across what seems another good reason for their prominence in the school when we interviewed Glenn, a senior year student in precalculus: "I like being involved in the competitions. Getting ready for them, you learn things like inverting matrices that you wouldn't ordinarily learn in class." It is difficult to gauge how many such topics enter the curriculum through competitions, but the pace of precalculus seemed slower at Deer Run than at other programs we visited, so it is believable that Glenn was on target in his assessment.

The pace of the curriculum was one factor that set Deer Run apart from the vast majority of the exemplary programs we visited. Another was the use of homework. In some of the Deer Run courses, students are permitted to do their homework in class, and teachers make themselves available for help. While this runs counter to the practices in the other programs we visited, and so is of questionable value, the practice was singled out by a couple of students from distant and isolated farms as valuable to their learning, because "it's hard if you get stuck at home on an assignment."

Given its small size, the mathematics program at Deer Run presents no complicated student placement challenges, and yet Mr. Atkinson was strong in his praise of the guidance counselor who had left at the end of the previous year, and equally strong in his disappointment in the performance of her successor. Apparently the former counselor had been a strong influence on the students, especially the girls; her departure, seen in the light of the recent turnovers in superintendent and high school principal, made the mathematics program seem a bit more vulnerable to us.

Because she teaches most of the courses, and because she is keen to meet all students' needs, Ms. Vandenburg risks overextending herself. On the one end of the curriculum, she saw the need to introduce calculus to the several students who exhaust the course offerings by senior year, and was planning to incorporate it as a semester course, combined with a semester of number theory. On the other end, she decided to introduce a prealgebra course for those ninth-graders who are not fully prepared for algebra, but who need something more challenging than general mathematics. While he was in charge, Sam Walker refused to allow her to teach prealgebra because of the time taken from planning. The new principal and superintendent have given their blessings, however, and Vandenburg was eager to get the course up and running.

Clearly, her hard work and dedication mean a lot to the program. After the careful planning of Sam Walker, they constitute the second major factor behind the progress of the mathematics program. She is the mother of two small children, with all the concomitant responsibilities and constraints that come from leading a double life. For example, our first morning in her class was interrupted by a call from her nursery school, whose staff had temporarily misplaced her younger child. Vandenburg seemed slightly envious that other math team coaches whom she knows are able to use after-school time to prepare their students for competitions. She cannot, because of her family responsibilities and because the majority of her students are dispersed at the end of the school day across the wide expanse of the school district, many to farm chores that will not wait. In any case, this dedicated teacher finds the time, during class, during lunch, during homerooms and preparation periods, to prepare students for the contests.

During her eight years at Deer Run before our visit, Vandenburg was the only full-time mathematics teacher and, although she lunches once a week with the part-time teacher so that they might coordinate their algebra teaching, she really has been a department unto herself. In so many of the programs we visited, continued success appears to be tied to the collegiality of staff and the strength they draw from each other. In that light, the professional loneliness of Mary Vandenburg seems all the more poignant, and her sustained enthusiasm and commitment all the more laudatory.

Her dedication, and the dedication of many of her rural teacher colleagues, has a special quality to it because of the relatively limited opportunities for young people growing up in an isolated community the size of Deer Run. There is a strong commitment on the part of these teachers to expose their students to as much as possible of what is new and different and to push them to open their eyes to it. This explains the special appeal of regional and state competitions as vehicles for program improvement and Mary Vandenburg's commitment to involve as many students as possible in them: "When freshmen come into our school they want to be part of that winning team. I have had students who are not taking math in their senior year ask if they could still go to math contests. I try to encourage all of them." Glenn, the senior quoted earlier, put it in a slightly homier way: "If the dumbest person came up to Ms. Vandenburg and asked to be on the math team, she'd find a place for him."

Money is an issue remarkably removed from the issue of teacher dedication in Deer Run (and, it is reasonable to assume, in communities like it). Generally in this school and community, there is a sense of pride in making it on very little. In the metropolis 50 miles away, a newspaper article appeared on the Deer Run schools under the headline "Excellence for Peanuts."

In any case, money has little bearing on Mary Vandenburg's dedication to the mathematics program. When we asked whether the master's degree she hopes to earn would increase her salary significantly, she looked surprised, even a bit annoyed by the question: "I don't know. That's not why I'd get it. I don't care what they pay me. I'd get it to help me teach better."

Money could definitely help the Deer Run High School mathematics program, however. There are spots where it evidently suffers from the district's skimpy financial resources -- for example, in training for broader teaching skills. We observed five classes and were struck by several aspects of the classroom interactions. For one, we were struck by the occasional impatience expressed -- by both mathematics teachers -- in the lower-level courses like general mathematics. Furthermore, the part-time teacher was often sarcastic in addressing her students, a behavior notably absent in the vast majority of classrooms visited in our study. Training for more flexible teaching skills could help.

A second disappointment was the lack of much development of student questions into further learning for the students. Vandenburg took the time to answer questions, but several of the answers we witnessed seemed to leave the questioners hanging. For example, as she drew a circle on the blackboard in her precalculus course, with radian and degree measures listed for angles, a student asked, "Is that a function?" The answer: "Sine and cosine are functions, but we haven't covered them yet." Then she went on with what she had begun. This was not only a confusing answer which did not satisfy the student, but it seemed a missed opportunity to spring from the question to a discussion of functions and trigonometric functions, in particular, and to get the students to voice their understandings and misunderstandings about the concepts. Later in the class, the same student came back with another question, during a discussion of odd and even functions: "Are parabolas and hyperbolas even functions?" The quick and somewhat unsatisfying answer from Ms. Vandenburg was, "Hyperbolas are not functions." Again, a missed opportunity to probe the students' thinking and to get them involved in a meaty discussion.

Mary Vandenburg's deep dedication to her students makes it clear that the missed opportunities and occasional careless behavior (such as inappropriate expressions of impatience) do not derive from a lack of concern. Rather, they derive from her professional loneliness as a department unto herself, and from the financial inability of the school district to provide much professional development. As it is, the principal stretches the budget to send her to state mathematics teachers' meetings and to the competitions.

Isolation and a lack of funds also have hampered Deer Run's attempts to expand its curriculum wisely. The grant proposal Mr. Atkinson has written to fund the purchase of the Elements of Mathematics materials for the high school's talented students, however nobly motivated, may be shortsighted. The materials are very sophisticated mathematically, and the program at Deer Run is not. Again, the geographic and financial isolation of the program has limited its options for finding appropriate curricular changes.

Conclusion

Sam Walker told us, from his new vantage point as another district's superintendent, "Deer Run High School has done more with what they have than any other school in the state." A biased and subjective assessment, no doubt, but it does reflect the truth about the school's valiant yet fragile efforts in mathematics.

In studying exemplary programs, our researchers travelled from inner city schools to suburban schools to rural schools. Each type has its own set of special challenges, and each has designed its own set of responses. In Deer Run's case, the challenges were a low budget and a traditional set of values that kept educational success on a rather low plane. Their response, through consistently forceful, supportive, and imaginative leadership and dedicated teaching, was to use a steady improvement in mathematics competitions as both a motivator for students and citizens and their standard for setting the tone of the entire mathematics program.

Success in mathematics continues to develop at Deer Run High School, yet it also continues to be a fragile sort of success. Funds are and always will be low; administrative turnover has been high, and the program relies on the deep dedication of one woman. Indeed, it is reasonable to say that, when compared with the other 27 programs we visited, Deer Run will have the hardest time sustaining its recent record of excellence.

* * *

TRINITY HIGH SCHOOL

Both students and teachers in the mathematics program at Trinity High School communicate an exceptionally high valuing of mathematics and high expectations for success in mathematics. Several particular manifestations are: the staff-designed general mathematics course that makes it possible and desirable for students to take more mathematics courses in later years; ongoing extracurricular problem-solving activities that involve students from all levels of courses: a couple of supplemental programs intended to improve the mathematical success of minority students: a mathematics team that keeps a winning record while involving students from every course level. The teaching staff is distinguished by a collegial and sharing attitude that adds consistency and firmness to the high expectations for student success. Their teaching skills also seem exceptional, especially in the kinds of questions and challenges used in the classroom.

TRINITY HIGH SCHOOL

> "Trinity is a hypercritical community."
> Principal, Trinity High School

> "To those of you sending students to Trinity High School for the first time, you need to know that Trinity High School teachers are demanding in many ways, and your student may have to study harder to achieve worthwhile grades compared to the previous school."
> From a letter sent to parents from the Trinity mathematics department.

Trinity was one of our diamonds in the rough, one of the schools we visited that exceeded the expectations set by their written applications to be part of our study. Certainly, Trinity was highly rated by our panel of program raters, but not as highly rated as some others we chose not to visit. We chose Trinity to enrich the variety in our study: it is a West Coast high school and so, geographically, it was different from most of our other candidate programs; furthermore, unlike most of our other candidates, Trinity submitted evidence that they paid special attention to enriching general mathematics and to guiding general mathematics students into algebra. In addition, the school boasted a high SAT average over recent years (consistently about 100 points higher in mathematics than in the verbal exam) and a relatively high level of extracurricular activity in mathematics.

Trinity turned out to be impressive in several ways. The sense of appreciation for and excitement about mathematics -- and problem-solving, in particular -- which the staff have generated among all levels of Trinity students, far exceeded what we expected. The teachers used some of the more innovative class challenges and questions witnessed in our study, and they have put several mechanisms in place that enrich the program from top to bottom -- a math team that involves students at all levels; several supplementary programs that not only provide content help, but also stress attitude and process; and a continuous, out-of-class problem-solving program that involves the majority of the students. Mathematics is a lively and influential enterprise at Trinity High School, and students pay attention to it outside the classroom.

At the same time, however, Trinity's mathematics program proved to be complex as well as exciting to study, a continuous challenge to the listening and observational skills of the two of us who spent three days there as site visitors. Personalities, politics, and philosophies are so enmeshed in this "hypercritical community," to use the principal's phrase, that it was impossible to look at any of the strong aspects of the mathematics program without hearing undercurrents of doubt and, occasionally, complaints and criticism. On the other hand, the energy level displayed among staff and students, the atmosphere of intense self-examination, the willingness to risk and challenge, all constituted an intriguing counterforce to the doubt and criticism.

Trinity is a small suburb of one of the West Coast's largest cities, a middle class town about a mile square with a mixture of what one administrator described as "working class and a growing number of university types," and a town in which almost all the housing is composed of single-family dwellings. There are three elementary schools, one middle school, and one regular high school (Trinity High School), and one small alternative high school in the district. Trinity High School, which comprises grades 9-12, contained 760 students during 1983-84, with an ethnic mix reflective of the entire district: 40 percent minority, consisting of 15 percent Asian, 15 percent black, and 10 percent Hispanic.

A variety of people talked with us about the mathematics program. A casual survey of impressions depicted a group of teachers who are firm, demanding, and hard-working:

- The Superintendent of Trinity Schools: "More demands are made on mathematics students at the high school than by other departments."

- The Assistant Superintendent: "The mathematics department held the students more consistently to high standards during the 60s and 70s than did other departments."

- A second-year mathematics teacher, who has taught in several other high schools in towns around Trinity: "In every school I've been in, the mathematics staff have taken far fewer absences than other departments. That holds true at Trinity."

- A senior student: "The math department is really organized. They meet in the beginning of the year and divide up responsibilities -- who will be in charge of math league activities, lunchtime contests, and so on."

What some in the community see as firmness and high standards, however, others see as shortsighted rigidity. Even the administrators, despite their words, seemed muted in their praise of the mathematics program because they quickly followed their praise by mentioning the criticism in the community that the program is weighted in its attention toward the upper and lower courses, thus leaving middle-level students with insufficient guidance. The superintendent and assistant superintendent spoke with us more with an aspect of curiosity than pride when they related how Trinity SAT scores in mathematics are consistently about 100 points higher than the verbal scores, and what pride they have been able to foster in the community seemed to them offset by their and the community's frustration over the early disappearance of minority students from the top sequence of courses. (In 1982-83, blacks represented fewer than 5 percent of the students in algebra II and precalculus.)

As with all the sites we visited in the study, we sought out general perceptions in the community of the mathematics program at Trinity High School. What we heard was extraordinary, both in its intensity and, especially, in its variety. The intensity signalled a community committed to educational concern and examination, but the variety of conflicting views of the mathematics program appeared to signal a process of examination carried out with insufficient care, where criticism has given way to blame much too quickly, often on too little evidence. One example, which concerns the entire school and not just the mathematics program, is the issue of students who don't live in the district. Because of its reputation for success in education, Trinity High School attracts students, mostly black, from outside the district. There are about 150 on record and, the principal advised us, probably another 150 who have managed to pose as Trinity residents. Somehow -- no one seemed sure of the origins -- the impression grew in the community that these students were a disruptive influence. The school board responded to complaints by approving a small study of the effects of outside students' presence in the program and the results, the principal proudly reported to us, pointed to the "safe and stimulating environment" fostered by the presence and participation of the students from outside the district.

There have been pockets of dissatisfaction and distrust in the school community, as well. The mathematics teachers at the high school have not fully trusted the middle school to teach algebra, now that eighth-grade algebra has become a reality in the district. (The department head: "The students who take eighth-grade algebra don't understand enough of the 'whys' of algebra to do well in our algebra II.")

From their side, the Middle School teachers have been equally dissatisfied with a relationship they see as lopsided and laced with prejudgment. "They see their way as always better . . . they find fault with us." It has been their perception that no credit is given to the Middle School for the mathematics preparation they provide, that after what they see as careful placement of eighth-graders in ninth-grade mathematics programs, the only report the Middle School gets is a printout of each student's high school grades, a meaningless gesture to them. Furthermore, they chafe at having received no credit for the concept of the general mathematics program when it was implemented with acclaim several years ago. Adding to the climate of mistrust, the high school mathematics teachers also have had a rather cool alliance with the school guidance counselors. (The department head: "They cooperate with us on student placement, but generally they think we're arrogant.")

Finally, and most unfortunately, the mathematics teachers have felt a lack of support from the central administration and the community. The department head told us that all of the academic course enrollments were over the maximum allowed by contract -- 30 students -- yet financial support to alleviate the situation was missing. A state proposition has severely limited tax money available to schools; the community has failed to pass several bond issues which would have made more money available for hiring staff; and, finally, a proposal to a local corporation for money to support the search for and hiring of a minority mathematics teacher was languishing at the corporation's end.

Even the students at Trinity High School seemed to inject an air of distrust into their academic lives. Their whispers and glances showed how suspicious they were of us during our classroom visits, and staff members described students' surprising wariness about enrolling in untried courses like the PASCAL computer course and courses taught by untried teachers. As one teacher remarked to us, "Kids at Trinity shop for courses on the basis of hearsay." Distrust is always a better base to build on than indifference, however, and when we passed the litmus test for these students, we found them in interviews to be among the most energetic, enthusiastic, and humorous group of students we encountered.

A similar bright side exists for the entire mathematics program, for while there are important avenues of support that have been closed off, several exciting avenues have been developed. For one, the local newspaper reportedly gives ample coverage to the school's successful mathematics teams; for another, an exciting and innovative supplementary program -- described below -- has been developed in conjunction with the nearby state university, a program which gives minority students a better chance to succeed in mathematics.

The mathematics curriculum at Trinity High School has been carefully thought out. The academic track includes algebra I, geometry, algebra II, and precalculus. Because the district maintains a minimum cutoff of 15 students per course, calculus is not taught at Trinity; students eligible for calculus may take it either at the high school in the town next to Trinity or at the nearby state university.

Since it is so small, Trinity has no honors program as such, but the academic track is very demanding. Students not likely to succeed in it may enroll in the sequence of courses that includes general mathematics, algebra IA and IB (algebra I spread over 2 years), and applied geometry. The school also offers a SAT math course for students who might not succeed in algebra II but who intend to take the SAT exam.

Several years ago the staff designed a general mathematics curriculum, of which they are clearly and understandably proud. In the words of the district's Director of Special Services, who composed the application to be in our study, the course begins with a one-month focus on basic skills, and then:

> "From the end of that time until June, the students see a variety of practical problems with a prealgebra orientation: area/perimeter/volume, percent/interest/sales tax, measurement of lengths and angles, consumer problems, equations. A cycling approach is used where new techniques are introduced periodically, used for a few days, then left for some time. They are seen again later in other types of problems.
>
> "Teachers have prepared a curriculum of 180 work sheets, one for each day of the year. Students receive a new sheet every day. A test is given every Friday."

The general mathematics program is given an added boost through the use of student tutors, who are either paid (through a state-financed School Improvement Program) or are given course credit for their tutoring. The philosophy that guided the staff in the development of their general mathematics curriculum was summed up by the department head as, "Give the students enough to succeed in algebra IA." There has been a strong commitment, expressed in a tremendous amount of time and effort devoted by the teachers, not to have general mathematics be the terminal course it so often is in other schools.

At the time we visited, the department's core, which comprises five teachers, had begun to express both concern and resentment about the general mathematics program, which they believed had been taken away from their control. In the previous few years, as the district moved to a two mathematics course minimum requirement, the academic courses grew in enrollment; in the meantime, the general mathematics program had grown from one section to four sections in the previous ten years. No money was made available to hire more mathematics teachers and the academic course duties of the core teachers have grown, so general mathematics has been turned over to a new, combined science-mathematics teacher and two vocational education teachers. They were using the curriculum developed by the Trinity veterans, but those same veterans feared that the philosophy upon which they based their development had been endangered. That fear gained stature for us in the rather stark and frightening admission of one of the new general mathematics/vocational education teachers to one of us after a class visit: "I don't know what I'm doing in there."

Peter Robbins, the 15-year veteran of the department, is in charge of a supplementary program (we'll call it the Development Program), arranged with the state university, an after-school program of tutoring and small-group work, set up primarily to support the mathematical growth of minority students. At the time of our visit, he was supervising 4 graduate students and university seniors who were working with 65 Trinity students in the Development Program. We observed one session, a very impressive one, in which the graduate student-teacher worked with a group of 16 on questions pertaining to an upcoming geometry test, had them break up and work in pairs on some problems, and throughout the session, worked in some appropriate coaching. For example, reacting to a side conversation of several students, she chided, "You can't expect to do well on the test if you continue to act that way." Then she challenged the group with interjections like, "Let's look at the types of question you can expect to see on the test, and discuss what's difficult about them"; "What can you say about the third sides of 2 triangles if 2 sets of corresponding sides are equal?"

The effectiveness of this student teacher was heartening; it was clear that Robbins was an effective mentor for this university mathematics student, and when we watched her interact with the students so effectively, we began to see this program as a potential model for attracting content-area specialists into mathematics and science teaching. Another heartening aspect of the program was partly accidental, namely the variety in the student group that was working so energetically after school: there were four whites, four Hispanics, four blacks, and four Asians in the group, and it was tempting to see that afternoon session as quintessentially American, a melting pot in microcosm.

Curriculum planning and implementation was strong in the high school mathematics programs, but it was isolated. Articulation with the middle school has been, as mentioned above, a sore point with the mathematics staff. Nancy Bernstein, the department head, also spoke of her desire to have some effect on the mathematics taught at the elementary level, especially in making more variety in problem-solving available to students, yet spoke also of her frustration at not having the time to do it. (Bernstein, by the way, was receiving only $250 extra in compensation to head the department, with no time freed from teaching for administrative duties.) She and her staff do meet once a year with the middle school mathematics people, but they have had little satisfaction in their attempts to change the quality of the algebraic understanding of eighth-graders.

Curriculum development and textbook use in the Trinity mathematics department mirror the development of the general mathematics program, in that the teachers use home grown ditto sheets (their "ditto-a-day" concept described in a later section), and, in their use of texts, they appeared very flexible. For example, Bernstein uses the Houghton-Mifflin Dolciani algebra II text, yet covers the matrices section first. Another teacher uses one series for class development, another for homework exercises.

Leadership was one factor we attended to in all the programs we visited in our study. Several circumstances combine to give it a special flavor at Trinity High School and in the mathematics department, in particular. Those in positions from which leadership usually emanates had little established foothold: the superintendent was in his first year; the principal was in his second year; and the department head had returned the previous year after a five-year break to raise a family. In contrast, the vast majority of Trinity teachers -- in all departments -- have taught only at Trinity High School and have taught there for a long time. They were also one of the most energetic and feisty groups of individuals we met in our school visits, and they evidently provide for themselves much that established leaders elsewhere provide their staffs: ongoing professional interactions, the sharing of materials and responsibilities, and that tenor of self-examination and criticism mentioned above. (Of course, there is a grey side to the feistiness, the occasional propensity to complain in isolation, to which we alluded earlier).

Despite the self-sufficiency that sustains the staff in their teaching and professional interactions, both the principal and department head do provide some vital aspects of leadership. The principal uses a mechanism that was refreshing to watch and promising for staff cohesiveness and communication. Every morning, at a time when the entire school takes a break from classes, he meets with all the teachers in their lounge. Serious announcements, humorous repartee, the sharing of home cooking, and slightly abrasive questioning all fill the twenty-minute get-together and, despite the occasional grumbling we heard from teachers, the meeting clearly could serve to draw the staff together in purpose. An example that occurred during our visit shows how the mechanism facilitates staff communication during a crisis: the principal announced that a student had been seen with a gun the previous day; immediately, the teachers pulled together to describe the student and her daily schedule and habits, and, in a few minutes, had designed a plan by which they could detain her, should she show up, long enough to get the assistant principal to her.

Bernstein, the department head, also showed her leadership in clearly defined ways. In particular, at the time we were visiting, she had measured the severity of her own and her teachers' complaints, had collected them in a memo, and was preparing to bring it to the central administration and school board. The list included dissatisfaction about a recent hiring of a mathematics teacher over which she had little say; a continuing sense of estrangement from the elementary and middle school programs; and a lack of financial support that had, in the eyes of the teachers, diluted the effectiveness of the general mathematics program they had so carefully built, by making it necessary to pass it on to teachers from outside the department with little attachment to and ownership of the program.

In one other aspect Bernstein resembled the best of the leaders we observed in the study: she works very hard and very long. As in some of the other programs we visited, the hard work is a mixed blessing in that it often approaches overwork and makes "burnout" a very real possibility. She told us she starts her day at 5:00 a.m. and goes to bed at midnight. In between, there are family matters and child care, but most of the time is devoted to the Trinity mathematics program. Weekends also, at least in part, are devoted to the program. Other teachers match the effort. As one veteran of 15 years at Trinity told us very matter-of-factly: "Sometimes Nancy (the department head) calls me at 11:00 at night and we plan for the next few weeks of algebra." The mutual respect on the staff and the teachers' obvious concern for Ms. Bernstein's treading near burnout were very moving to hear about and observe.

Although eight people teach mathematics at Trinity High School, only Nancy Bernstein is a full-time mathematics teacher. Another woman, in her second year when we visited, teaches only mathematics and computers but does it on four-fifths time. The other three core mathematics teachers, who all have taught mathematics at Trinity for more than ten years, also teach science. The remaining three teachers, who teach general mathematics, double as either science or vocational education teachers.

The development of the general mathematics course typifies two qualities of the mathematics teachers at Trinity that seem essential to the strength of the entire program: the willingness to work very hard for their ideals, no matter the cost in time, and their resourcefulness in making that work count. In other words, despite the occasional complaining, the teachers find ways to get done what they feel must get done.

Much of the time is spent by teachers implementing what they refer to as their "ditto-a-day" approach to courses. Among the five teachers at the core of the department, we sensed a general dislike for straight textbook approaches to teaching. In particular, they didn't like the sequencing of many topics and they especially did not like the lack of variety in problems. Consequently, they produce daily ditto sheets of mixtures of problems for homework. If two people happen to be teaching the same course, say algebra, they split the duties, two weeks of dittoing by one person, then two weeks of dittoing by the other. In the case of the precalculus teacher, in her second year at Trinity, the responsibility is hers alone. She uses the Harcourt Advanced Mathematics text for explication but likes the Houghton-Mifflin text better for problems, and so she hands out daily sheets of mixed problems, review as well as current.

This same woman showed her resourcefulness in other ways. It was she who arranged the calculus option for Trinity students at the neighboring high school. She also teaches the AP PASCAL computer course from her own notes, and when only a handful of students enrolled, she scoured the hallways, library, and cafeteria and enlisted students until the minimum of 15 was met. (As we have noted, Trinity students are notoriously suspicious and wary of new courses and new teachers.)

The dedication and resourcefulness of Trinity math teachers are evident in one other established practice, the Friday problem sheets, collections of challenging problems traditionally handed out by teachers in all of the academic courses. Teachers varied in the amount of credit they attached to solutions and the amount of time they gave students to complete the sheets. (A week was the minimum). At the very least, however, teachers give credit for attempts at solution, and they do not penalize for unsuccessful attempts. Before the due dates for the Friday sheets, teachers and students may discuss difficult problems in class, with, as we observed in one class, the teacher giving suggestions for new attempts to solve the more difficult problems. The effect on many students is galvanizing. Two seniors told us they estimated that at least half of the students in algebra II and precalculus have a go at the problems, and that it is not uncommon to hear them discussed in the student cafeteria. They also claimed that regular attention to the Friday problem sheets facilitates a smooth flow through the curriculum, that it is easier for students to see connections among concepts. As an example, they recalled a teacher who reinterpreted several geometry problems from the Friday sheets algebraically, thus giving the students a previously unseen bridge to the mathematics of another course.

At some of the exemplary programs we visited, we observed teachers who attempted to teach students how to learn mathematics as well as merely teaching students mathematics. We saw examples of this kind of teaching at Trinity. Just as the mathematics teachers refused to be limited in content and sequence by course textbooks, so they also refused to be limited in their classroom strategies by the canonical model of teacher talking at students. They often coached, cajoled, guided, and chided. Here are three examples:

- Peter Robbins, the Development Program coordinator, gave a problem in his algebra I class and had the students work on the problems in small groups. ("Don't offer your answer until you get three people in your group to agree on the answer.") The ensuing discussion was lively and fruitful. (Robbins to us, later: "I couldn't have done that before the Development Program. It showed me what a useful and powerful tool student peer interactions can be.") Later in the same class: "There is a special relationship between the slopes of perpendicular lines, and the book doesn't say it explicitly. What is it? Don't shout out your answer until you check it out with someone near you."

- In her algebra II class, Nancy Bernstein asked for an explanation about the convergence of a particular series. When the original student's explanation drew blank expressions from the rest of the class, the explanation was bandied about and refined until it was more understandable. To the first student: "I know that your explanation was correct, but you didn't say it so others could understand it." This was only one of several examples we witnessed of urging students to refine their mathematical reasoning and explanations.

- The second year teacher of precalculus polled her students on the problems from the previous night's homework sheet that caused particular difficulty, then told them to work on them in small groups for 15 minutes with the direction: "Choose your groups carefully. Pick someone to work with who knows what he or she is doing in the area where you need help." The groups were lively, on task, and in our view, fairly successful at covering the troublesome problems.

By their own assessment, the work load of the mathematics teachers has kept them from helping each other as much as they would like, and has kept them from attending to the newer teachers, in particular. It thus threatens to dilute their well-conceived general mathematics program. In our view, it also threatens to waste some of the refreshing classroom dynamics we witnessed. To amplify on a previous example, there was little follow-through on Bernstein's "you didn't say it clearly enough so others could understand it" interjection. The student to whom the comment was directed was left to sit silently and apparently confused by the advice. But there were 33 students to attend to in the class -- with a range of abilities (since there is no honors level), so the lack of follow-through, while unfortunate, seemed unavoidable.

The Friday sheets dovetail nicely with Trinity's approach to mathematics competitions. Together, they constituted one of the best efforts we witnessed in our study to generate enthusiasm for mathematics outside of the classroom. We saw a variety of approaches to competitions in our site visits, but none that was as broad in scope as Trinity's. The teachers want to see all students -- not just the top students -- involved. As Robbins recalled: "We thought through competitions very carefully 15 years ago. First of all, we instituted weekly in-school competitions, then began taking students to local competitions. They did badly at first, but we began to note an improvement in achievement on the national exam of the Mathematical Association of America, even among average students. We also noticed that, through the competitions, we were asking the students to integrate their classroom mathematics learning." At that point, the teachers began the Friday sheets to feed this trend toward integration and improvement.

Now Trinity excels in their league competitions, yet their commitment is still toward all the students. More than 50 students gather with teachers for lunchtime versions of the Atlantic-Pacific Mathematics Competitions. Shortly before we arrived, Trinity brought six five-person teams to a league competition. The veteran teams scored high enough for Trinity to win the competition, but what impressed us was the account by the assistant principal, who drove students to and from the competition, that the older students were debriefing, consoling, and coaching the younger competitors all the way home. Again, these younger competitors were not all stellar students. Indeed, in one class we heard one of the teachers urging students from the Development Program to take part in the next competition. When we began to think of Trinity as a diamond in the rough, we had in mind this consistent commitment to maintaining a mathematical environment in the school, one that embraces the vast majority of students and prods them toward excellence.

The students seemed to be thriving in this mathematical environment. As one student answered our question about what makes Trinity's mathematics program so successful: "Easy, here kids help each other learn, and the teachers help kids. If I were a student in the high schools that we compete against, and if I asked another student for help, he'd be likely to cover his paper with his hands and tell me to figure it out myself. Here at Trinity we cooperate with each other."

Summary

With their extraordinary efforts to enrich the content and sequence of courses as well as classroom dynamics, with their nurturing of institutions such as peer tutoring, the Development Program, the Friday problem sheets, and the mathematics competitions, the mathematics teachers have created a dynamic as well as exemplary program. And yet, as we mentioned at the start, tension shows through the fabric of the program almost constantly.

As the principal told us, Trinity is a "hypercritical community": parents/voters criticize the scope of the mathematics program and withhold their support at the polls; students show a tendency to respond to rumors and stay away from anything unfamiliar, such as a new computer course or a precalculus course taught by a relatively new teacher; the high school mathematics teachers criticize the middle school mathematics teachers and vice versa; the high school mathematics teachers are very wary of administrators and critical of their lack of support; and despite their words of support for the mathematics program voiced to us, the administrators seem somewhat muted in that support and appear caught between community criticism and their own admiration for the breadth of the mathematics teachers' efforts and success.

When a group of teachers such as the Trinity High School Mathematics Department struggle and succeed, in general, despite pockets of failure, it seems essential that the surrounding community of administrators, parents, voters, and so on, focus primarily on the success and effectively communicate their support for the efforts and their appreciation of the success. That communication of support is regrettably missing in Trinity; blame arises much too quickly, and the struggles of the department will probably continue. For our part, we believe we saw at Trinity several program facets -- especially the well-defined approach to problem-solving and competitions, the well-organized approach to supplemental help, and the well-conceived approach to general mathematics -- that can stand as exemplary models for many other schools.

* * *

SILVER VALLEY HIGH SCHOOL

Effective planning and management are central to the success of the mathematics program at Silver Valley High School. The teaching staff, which enjoys remarkable longevity of experience at the school, is well trained in teaching techniques and classroom management. They also have retained much of what was exemplary and most useful in the curriculum development of several decades ago and continue to incorporate it into their curriculum. The use of computer materials seems exceptional in its range and quantity. Leadership is central to the success of the program, with the department head setting the tone for the consistently high expectations and constant vigilance that guide the program.

SILVER VALLEY HIGH SCHOOL

> "What makes our program successful? Well, for one thing, we stay on top of every student."
> Mathematics Department Head, Silver Valley High School

A striking feature of exemplary mathematics programs is their insistence on getting the most out of their resources, both material and human. They identify goals, plan how they will reach them, and then stoke whatever fires are available to them. The better ones take absolutely nothing for granted in this process -- not past laurels, nor the professional backgrounds of their teachers, nor the family or school backgrounds of their students.

One of the best of these is Silver Valley High School. Seemingly reluctant to rest in its comfortable suburban setting, the school has put together an extraordinarily comprehensive mathematics program, which grasps in all directions in its pursuit of excellence. In a professional community where parent interest in mathematics education might safely be assumed, the mathematics department has one of the most persistent programs of parent communication that we observed in our study. In addition, they have established an elaborate program of student placement and monitoring, and a carefully planned system of teacher training and evaluation. As a result, expectations are high on all sides and attention to accountability -- for both staff and students -- seems everpresent. The program has set out to keep all participants on their toes, and it has succeeded admirably. It was one of the most carefully planned programs we visited in our study; little is left to chance. If teaching mathematics is part art and part science -- with the blending dependent on individual situations -- then Silver Valley leans heavily on the science end of the formula.

Silver Valley High School serves four small, modern, middle-class suburbs of a large Midwestern city. Its single-level, sprawling campus sits close to an interstate highway that is a straight ten-mile shot to the central core of the city. Because of its convenient location and record of excellence, and because it was amenable to the challenge, Silver Valley became the first school in its state, in 1976, to take part in an interdistrict busing-for-integration program. Since then, the school has admitted about 25 black students from the city each year.

Like many middle-class suburban schools, the school has a rapidly declining enrollment. In 1976-77, it served 2,100 students; in 1983-84, there were only 1,660 students; and projections for 1990 picture a further decline by several hundred. Unlike some other victims of a similar decline, however, Silver Valley shows none of the wear on staff morale or tear on its curriculum. It was not the wealthiest school we visited, but it is evidently comfortable enough to hold steady on its course. The district ranks among the highest in its state in value per student. At the time of our visit, its annual expenditures per student were $3,225 for educational purposes and $550 per student for transportation, construction, and debt service. The high school has managed to retain a teaching staff in which 80 percent have master's degrees or higher, and an average student-teacher ratio of 15:1. The academic stamp on the school is clear: about 85 percent of its graduates go on to college -- more than 75 percent to four-year colleges.

While the school as a whole has been shrinking, the mathematics program has been thriving, with a rise in the six years preceding our visit in the percentage of students enrolled in mathematics courses. In a school that has required only one year of mathematics, the figures have been impressive: 16 percent of the students who graduate have taken at least one semester of calculus; 90 percent of the students take both algebra and geometry courses. Most impressively of all, perhaps, more than 90 percent of the students in the ninth-grade arithmetic skills course go on to take a full four years of mathematics. In addition, the school has maintained an average SAT score in mathematics (539 in 1982-83) well above the national average (467), despite the relatively large number of students taking the exam (more than 220 in 1982-83 out of a graduating class of 420 students).

These statistics attracted two site visitors in Silver Valley for a three-day visit in October 1983, as did the school's sound record in mathematics competitions and the extraordinarily high level of student involvement in computer programming and in using commercial software to supplement their mathematics courses. (The school was the first in its state to use computers in instruction, in 1967.)

We had selected some other programs to study that were relatively new to excellence in mathematics, some even where change and experiment seemed central to their excellence. Here, in Silver Valley, was a program with an extended acquaintance with excellence, yet with the sustained impetus to keep improving. Like the interstate highway the school abuts, like its campus, and like the communities it serves, all of which are modern but not brand new, the mathematics program has reached a level of maturity that is still young and fresh. It combines maturity with a vision for improvement, and it was explaining this combination that challenged us as site visitors.

One manifestation of maturity in Silver Valley's mathematics program is the staff, which has enjoyed a remarkable longevity. In describing the role of the mathematics teachers within the school, the principal referred to them as "our stalwarts, our watchdogs on excellence," and talked of their dependability during the shaky days of the early seventies, when experimentation in education -- often shallow -- was the national rage. Of the 16 teachers in the department, 10 have been part of the program since the 1960s. Along the way, several others have been lost to industry and to other schools, but the core has stayed together since the early days of the program. In part, but only in part, this record is explained by the ability of the district to pay well. The principal estimated the school's salaries to be the highest in the state for teachers with master's degrees plus 30 hours credit (top salary: $36,000).

Not that money flows freely for the mathematics program. The five-member school board (selected from the four communities) that oversees the high school has proved it can maintain a tight grip on its purse strings. The school's computer coordinator, a mathematics teacher, had to make eight presentations to the Board before they would release the money to buy the 32 Apple computers he was requesting. Granted this was a considerable investment, but with the school's remarkable track record for computer use, the safety of the investment might have seemed assured. In any case, there are two telling comments about the mathematics program in this story. First, they have been well supported in material resources (24 of the computers went to the mathematics department), albeit with occasional struggles. Second, and perhaps more telling for an analysis of the program's success, they were willing to persist, to go back before the Board that eighth time, to get what they felt they needed.

The Board oversees only the high school. Each community has its own elementary and middle schools, and its town boards governing them. Because of the solitary focus of the Board, the principal is really a district administrator and deals directly with them. In that sense, the communities are closely connected to the school and thus to the mathematics program.

Beyond that, we saw no evidence of direct parent involvement in the program. It seemed, however, an absence born of trust and satisfaction, because the department is assiduous about communicating with parents. "It is the chairman's responsibility to deal with the public," we were told by John Young, Silver Valley's mathematics department head, and he has instituted some practices to make it happen. There are mailings that explain the course offerings, the homework policy, the placement and monitoring policy, and the advanced placement program. There is also a parent guide to good home study skills. Eight student reports go home, four in the form of quarterly grades and four in the form of mid-quarter progress reports. Parents are involved in student course changes or when a student moves from one curriculum track to another. And the department keeps a record of every parent phone call on student placement: who called, the nature of their message, and the resolution of their conversation.

Both Silver Valley High School and its mathematics department have been shaped from long and deep convictions about the role of leadership in education, primarily in the thinking of Harold Cabot, the principal, and John Young, the mathematics department head. Each man seems to recognize the incontrovertible yet too rarely accepted fact that educational leadership fails if it does not both exalt teachers and genuinely challenge them to grow as professionals.

"I have always maintained that teachers are managers," Cabot said, "and should be treated and trained as such." With that conviction as a guide, he pursued several basic changes when he became principal over a decade ago. He eliminated lavatory and lunch duties for teachers, reorganized the physical space within each department so that every teacher has space of his or her own in which to work, and began a systematic program of professional development. He "talked the Board out of a top management model" and sold them on his model, one in which department heads assume a larger share of managing their departments. Each department head is responsible for his or her departmental budget, curriculum development, and hiring, and shares the responsibility for teacher evaluation with another department head. Thus, John Young and the head of the science department share the responsibility for evaluating the mathematics teachers. Other departments have similar arrangements. It seemed a clever mechanism that allows evaluation by people close to the material being covered in the classroom, while guaranteeing that the evaluation includes the perspective of someone who is not too close to the people being evaluated. When the mechanism was set in place, Cabot sent all the department heads to be trained together in supervision. Department heads are officially administrators at Silver Valley. Each teaches two courses, and each is through teaching by 10:30 in the morning, so that departmental administration can flow unimpeded throughout the remainder of the school day.

Cabot's delegation of authority applies to parent relations as well. "I don't deal directly with parents. We urge the parents to deal with the teacher directly, or if not the teacher, the department head."

Evidently, Cabot's delegation of authority is extensive, so extensive that his management structure dominated our conversation with this mild-mannered but strongly opinioned man and made his rare comments about pedagogy seem almost out of place. On the surface, his brand of leadership seems to fly in the face of the bevy of recent recommendations about effective school leadership, which generally include some variation on the rule that effectiveness suffers in proportion to the distance of the school leader from the classroom. But the surface impression ignores the fact that Cabot has created a team of active school leaders within his school, whose representative in the mathematics department, at least, is an exemplar of the recommendations from the effective schools literature.

John Young is as mild-mannered as Cabot, and so appeared to us quite different from the many intense, emotional, even volatile department heads we met in our visits to exemplary programs. After several days of observing his controlled and patient demeanor, it came as no surprise to us to learn that he is a talented magician by hobby and produces an annual magic show for the school. Just as with Cabot, however, Young's mild manner belies a store of strong opinions about education, opinions that have set the tone and shape of the mathematics program in the 15 years in which he has been department head. During that period, he has earned the respect of colleagues throughout his state for the evident success of his program, and has gained national recognition from his book on effective teaching techniques in mathematics, published by the National Council of Teachers of Mathematics. Furthermore, when we visited he had just returned from the White House, where he had received his state's Presidential Award for mathematics teaching.

Thus the cachet of Young's opinions is unquestioned, yet we found his expression of them, while firm and confident, to be refreshingly free of pontificating:

- on teacher growth -- "It takes three years before a teacher contributes more than the text."

- on homework -- "It is essential. When I supervise, I specifically watch how teachers handle students who don't do homework."

- on his program's success -- "If I were to try to reproduce the program's success elsewhere, I know two things I would stress: K-12 coordination, and staff involvement in professional meetings -- at least one a year. If you come back with two ideas, it's worth the expense and effort. Just to talk and meet with other people makes it worth it."

Young's supervision of his teachers, shared with the science department head, is extensive. New teachers are observed in class ten to twelve times per year, sometimes without prior warning, and the supervisors follow their visits with criticism and some training, often based on Young's book. Veteran teachers are observed in class two or three times per year.

Coordinating curricula is very important to Young. He meets with the head of the science department periodically to review how well the two departments are nourishing each other. (Young gave us an example of an issue that might highlight such a meeting: "Is the mathematics in the science courses too tough?") He meets once a month with the staffs of the elementary and middle schools whence his students come. Together they discuss curriculum issues and student placement, which is based not only on standardized tests, but also on eighth-grade teachers' ratings of study skills and the recommendations of a committee of mathematics teachers. Young also has worked with the middle school staffs to develop a test to be used for eighth-grade placement. The head of guidance at Silver Valley told us: "The mathematics department has done more than other departments in K-12 coordination. They have, for example, held inservice sessions with the middle schools in content areas that needed stressing."

There is one facet of the middle school curriculum where Young's opinion and influence have been unbending. He and his staff are adamant about there being no eighth-grade algebra in the district. Instead, to accommodate the brightest eighth-graders, Young is developing, with the middle school teachers, a course that comprises some prealgebra, statistics, logic, and nontraditional problem-solving. Within his own department, Young has delegated some of the responsibility for curriculum coordination to faculty committees within subject areas. Thus, algebra 1 teachers form a committee, as do the geometry teachers, and so on.

Generally, the expression "tight ship" applies to the system Young has set up. He does not like to see any leaks or weak links and, when he spots one, he moves to shore up the system. During the course of our several conversations, he had remarked that student respect for and attention to homework have recently been (in his eyes) unsatisfactory at Silver Valley. The department's homework policy is exceptionally firm -- offenders are required to stay after school to make up neglected work -- and it is routinely enforced, yet Young still perceives a problem to be overcome. As we parted, shaking hands, at the end of our visit, he briefly summarized the program's future for us and then added, "We're not going to give up on homework!"

Not giving up also describes the history of the mathematics curriculum at Silver Valley, but with a slightly different twist. Unlike many of their colleagues around the country, the staff veterans who began teaching in the sixties liked much about the School Mathematics Study Group (SMSG) "New Math" materials, latched onto them, and have not let go since. One of the teachers has even invested in hard covers for SMSG materials in order to preserve them for the precalculus he teaches. John Young has adopted the SMSG logic materials and problem sets for his honors algebra I. The materials have survived only in a few courses but, nonetheless, as my site visitor partner exclaimed after one class visit: "The new math is alive and well at Silver Valley!"

It is alive and well also in the way it informs textbook decisions. When we interviewed both Young and several of his geometry teachers, they were pleased with their choice of a new geometry textbook (published by McDougal/Littell Press) that uses algebra as a primary vehicle for approaching geometry. (A typical procedure might deduce information about a triangle through the use of simultaneous equations.) The integrated approach obviously appeals to their SMSG-rooted sensibilities.

This text was being used in the two middle tracks (of the four tracks) of geometry. An informal geometry text was used in the lowest track, and two texts -- one on integrated geometry, the other on analytic geometry -- were used in the honors course. More generally, the four tracks or levels of the curriculum are Honors (accelerated and enriched calculus), A-level (enriched calculus), B-level (precalculus), and C-level (non-precalculus). Students are placed in the different levels through a procedure described in the following brochures for parents:

> "A student's initial placement in a particular subject is based on the level of performance as assessed at the end of the eighth grade. The initial recommendation for placement is made by departments after careful study of the following criteria: seventh/eighth grade achievement, reasoning ability, interest, Silver Valley Achievement Entrance Examinations, national standardized achievement tests and aptitude tests, and eighth-grade teacher recommendations.
>
> "Flexibility in course placement is a continuing practice in each department each school year. Recommendations for course changes are based upon achievement and interest, in addition to parent approval. Course changes may occur at any time. A student and/or parent may request a review of placement any time during the four years. Such requests are directed to department chairpersons."

The commitment to appropriate and flexible placement continues well into the school year. For instance, there is a course called A/B algebra, for students whom the staff have identified as having the potential for doing A-level work, but who lack the appropriate study skills. During the first semester of the A/B course, the teacher puts special stress on study skills, through careful attention to correcting test problems and through individual attention to students in class. At the end of the semester, those who seem to have realized their potential move to the A-level course; the rest of the students remain together and the course becomes a B-level course.

Complementing Silver Valley's placement system is their monitoring system. Some of it, such as the nurturing and observing in A/B algebra, is relatively informal. But the department has also formalized monitoring to an extent, in part at the behest of Cabot, the principal. As he told it, around five years ago they discovered that approximately 120 of their students did not have the skills to survive the eighth grade, never mind the rigors of high school. The discovery served to prod the Board into funding a clinic with a full-time aide. The clinic, which costs about $8,000 a year to maintain, has several uses. First of all, it supports the efforts of the mathematics department in guiding students safely through the minimum competency test all students take in their junior year. A screening exam in freshman year alerts teachers to the students who will find it tough to pass the competency test two years later, and those students are urged to take advantage of the clinic in their free time. Once a student has failed the competency test in the junior year, however, he or she is obliged to visit the clinic during free time. (This illustrates the tone and level of influence in the mathematics program, since passing the test is not required for graduation.) The clinic is thoughtfully hidden away to make visits more palatable. Even so, Young told us, "The aide is prepared to drag the students in from the hallway". A second use derives from the departmental homework requirement: students who are delinquent in doing homework must spend time in the clinic after school.

Cabot and Young instituted one other mechanism to buttress students' chances to pass the minimum competency test: the so-called skills maintenance worksheets. These brief basic skills quizzes are administered each Thursday at the beginning of class. Typically, there are four or five exercises built around one topic. An example of an exercise from the percent worksheet is: "Sara wants to enter 12 3/4% on a calculator without a '%' key. What decimal number should she enter instead?"

To sum the curriculum story so far, the Silver Valley mathematics curriculum is divided into four levels. There is some traditional textbook use, as well as several courses in both the high and low levels where teacher-developed materials are used instead of texts. Some of these materials contain vestiges of the SMSG materials of the 1960s. A comprehensive placement and monitoring system supports the curriculum.

No curriculum implementation is ever perfect, and some tarnish showed up at Silver Valley when students talked about the differences between the honors H-level and the other levels. Several students told us that it was not uncommon for students to be eased out of the H-level because of their unsatisfactory work, and then for them to "coast" through A-level courses with A's. Whatever the real facts are, it was clear that the students perceive the four levels to be two levels -- honors and nonhonors -- with a wide gap in between.

The one other notable component of the curriculum is the computer curriculum, one of the best that we saw in our site visits. In fact, it represented the best combined use of programming, course-related tool software, and general software of any school we visited. Of the school's 48 Apples, 24 belong to the mathematics department; they are divided evenly between two labs, one of which is reserved for use within mathematics courses, the other available for individual student use during free time (between 7:00 and 4:00). The two labs are separated by a glass partition, and both are observable from the office of one of the mathematics teachers, Mr. Cosgrove, who can both monitor use and assist classes who are using the computers. Apparently, not much monitoring is necessary, as Cosgrove reported to us: "We've told them that we'll close it down if they abuse their privileges. They police it pretty carefully."

All programming courses are elective and, at the time of our visit, there were 320 students "actively involved" in them. The courses were being replanned during our visit. Programming I and II have been semester courses in algorithm construction using BASIC, and advanced programming a course involving projects, which students could repeat as often as they liked. In the new design, programming II would concentrate on LOGO, and advanced programming would include machine language. In addition, the staff (the four who teach computer courses) planned to institute a less formal version of programming I for C-level students. Cosgrove talked with us about one engaging as well as ambitious idea he has embarked on: to work with the school's industrial arts department to build a robot -- programming students doing the programming and shop students doing the assembly.

Silver Valley seemed like most other schools in their experimentation with programming, confronting questions about which languages to teach, how to guarantee wide access, and so on. And a few of the more common problems have cropped up in the program. For example, female enrollments drop way off after programming I (15 out of 16 students in programming II were male).

In one aspect of their computer curriculum, however -- using the computer to support course work -- Silver Valley seemed much more settled and mature than its counterparts around the country, a phenomenon that has no doubt derived from the mathematics department's long association with computers in instruction. Geometry courses have built-in programming components, and Cosgrove described how, when he works with C-level students in programming I, he takes time to teach the working of such things as the slope and quadratic formulas. When other teachers reach certain topics in algebra, trigonometry, and analytic geometry, they are welcome to bring their classes for a computer session with Cosgrove's help and the help of the department's bank of tool software. The bank included some of the graphing software of MECC and Scholastic, Inc., Addison-Wesley's conic sections and trigonometric functions software, and Math Software's Super/Math Package.

To place it in perspective, the well-organized computer use was typical of the entire mathematics curriculum and its implementation. All tests were computerized and all courses designed by objectives. So when Young, the department head, sets out to search for new textbooks, he takes his cues from the course objectives.

When the teachers want to take the pulse of their placement program, they can juxtapose computerized test results with computerized placement records (complete with records of parent involvement). The program stood out to us as an exemplar of superb management, with very few blind spots. One possible blind spot is female involvement in advanced courses; we heard little concern expressed about the male dominance in a few of the courses (15 out of 16 in programming II; 18 out of 24 in honors precalculus; 12 out of 19 in advanced placement calculus AB). Another weak point has been representation of black students in upper levels, but Mr. Cabot, the principal, was optimistic: "I sense an upward movement of the black students. When busing began, they were all C-level students. Now there are some at the A- and B-levels, as well." Whether the optimism is warranted remains to be seen. As noted above, many students, both black and white, perceive a sizable gap between the honors and non-honors levels, and the staff will have its work cut out to eliminate this perception of a program divided into two classes -- the select and the non-select.

As might be expected in a department where 10 teachers have been together nearly 25 years, in a school whose principal actively cultivates professionalism among his staff, the 8 Silver Valley teachers we observed were, for the most part, models of effective teaching behavior. To our eyes, they obviously planned well, stayed on their planned courses, used class time to its fullest, engaged their students in active discussion, and so on; in short, they were exemplars of the recommendations of the effective teaching literature. We could fault them on only one ground, one that plagued most of the programs we studied and one that clearly haunts all teachers who feel hard pressed to cover material in their textbooks. When a crisp pace to classwork is prized, then many students are left to sit silently in a state where neither teacher nor even class observers can be sure they are understanding what is going on. Such was the case with classes we observed at Silver Valley.

Of course, the teachers' disciplined approach to teaching is understandable, since Young's book has played such a central role in staff training and evaluation at Silver Valley. But their commitment to perfecting their craft predates the writing of the book. The older teachers are almost all veterans of the National Science Foundation summer training of the 1960s. The grand prizewinner in that category is Cosgrove, who counted off nine in which he had participated, in a variety of settings around the country.

What was less expected were the range of teaching approaches in the mathematics courses and the dynamism of most of the veteran teachers. The latter was impressive in light of the long experience of the majority of the teachers, decades in the classroom that easily could have dulled their edge. As for the teaching approaches, we saw combinations of whole-group discussions, small-group work, team boardwork, individual seatwork and boardwork, and individual student recitations and explanations at the board. Different teachers used different combinations; those who aim for variety talked about their reasons for using the techniques they chose, usually to have some effect on the students' expectations or to improve study skills. Mr. Bardak, who teaches honors precalculus, told us: "Right now, at this point of the year, I have started them off with small-group problem-solving. When I call on a group, they choose one of their group to report on their work. Pretty soon, I'll move toward requiring them all to be prepared, so that I can call on anyone."

Here it was again, another manifestation of one of the most universally powerful factors we encountered in our site visits -- the communication of high expectations. But it was not hard to see and hear manifestations throughout the program. A conversation with several students -- black students bused in from the city -- made it especially memorable for us. One of the students remarked that the program had been good for him. Asked why, he said, "Mr. Young makes you do all this homework, and you do it." "Or," another added laughingly, "you don't take math."

Young's book recommends the use of overhead projectors in class discussions -- both to present new material and to pose problems. We saw the projector used in more than half the classes that we visited. The book also recommends seating students in a U-shape to facilitate discussion. That, too, we observed in several classes, although traditional seating was more the rule.

The quality of teachers' classroom interactions was high in most of the classes we visited . (One exception was the AB advanced placement calculus, where the demands of the material, particularly the amount, seem to legislate against much thoughtful interaction or time for student interpretations. This, by the way, was typical of most of the AP courses we visited in programs around the country; a fast pace seems to supersede other values.) In the Paideia Proposal, Adler wrote about the three roles of teachers: to deliver information, to coach, and to stimulate thinking. We saw examples of all three in the Silver Valley program:

Mr. Young's honors algebra I:

- "Put this in your notes."
- "What's wrong with $-3 \geq x > 7$?"
- "Those are not the right words, but that's the right idea."
- "What do you observe about these statements?"
- (to a student who suggested a solution to an inequality, then discovered it didn't work.) "That's good. It gives us information about something that doesn't work."

B. Mr. Tadisch's B-level geometry:

- "What can you say once you know these 2 angles are equal?"
- "Everyone stand. When you see the error in Judy's proof, sit down -- that's good! Five people were left standing. That means they were saying they didn't understand. They gained something."
- "Nobody has a solution? Okay, pull together in small groups with your neighbors and share your ideas."
- "That approach looks promising. Get on that horse and ride it!"

Tadisch, who coaches baseball, appeared to have a welter of strategies up his sleeve. A few are definitely of the corny variety, but they seemed to appeal to his students. One is called "The Top Ten Hustle." Tadisch puts a problem on the overhead projector, and as students complete it, they rush up silently to show him their answers. The first ten who are correct are awarded numbers, somewhat in the fashion of the finishes of a cross-country race.

We asked David, one of the students in this course, to describe its outstanding features: "I like the different techniques -- the overhead projector, the problem work in small groups, the board work. They help me get the stuff down better. I also like the different ways Mr. Tadisch finds to give all the students a chance to do well. Like his 'Mulligans' -- surprise quizzes that only count toward the grade if you do well." About what might make the entire program work so well: "I can always get help anytime after 7:30 in the morning. I may not get to work with a particular teacher, but I know that someone will help me."

Of course, teacher availability is a built-in feature of Cabot's grand design for a school where teachers can concentrate on managing students' learning and their professional growth. Eliminating lavatory and cafeteria duty did not necessarily make life easier for the teachers. Their typical course load has grown from four classes a day to five, and the district requires that they be available to students from 2:30 to 3:45 every day. As David indicated, however, teachers typically go beyond what is required of them. During the school day, students needing help can check in with the aide in the clinic or catch a free teacher at her or his work space in Young's outer office. Ms. Brodski, a second-year teacher, uses her two planning periods during the day to call parents, alerting them to any coursework trouble that might loom for their children. She teaches primarily at C-level and bemoaned the lack of concerned parent response that she saw as typical of that level.

If there is a gray side to this exemplary program, an area where the efforts are not quite so sharp as they are elsewhere, it is C-level. To be sure, if 90 percent of the students at that level take 4 years of mathematics, the problem cannot be severe, but the classroom interactions seemed less sharp there and the teacher behavior less dynamic. Teachers of the A-and H-levels hardly ever teach B or C courses, and the same is true of B- and C-level teachers teaching A- and H-levels. (The arithmetic skills course has been taught by the same man for nearly 20 years, and he requests it each year.)

Interestingly, while the staff showed little concern about this situation and, indeed, seemed satisfied with it, some of the students cited it as a shortcoming. Without doubt, it contributes to the widespread student perception of the gap between the upper and lower levels. In a touching show of care for their peers, a gesture that was reproduced at other exemplary sites with a similar situation, Silver Valley honors students gave us one or another variation of: "The best teachers teach the upper level courses. I wish the lower level students could have them as teachers, too." No matter how accurate their assessment of the teachers, the students' lament serves as a warning that the program's unquestioned excellence is tainted with perceived inequity, at the very least, and staff decisions about course preferences have done little to mitigate the perception.

There is one other aspect of teaching and staffing that was important at many mathematics programs we visited, namely, the collegiality, teamwork, and sharing among the staff. At Silver Valley its influence seemed muted, though we were told that it does take place informally. Cosgrove mentioned the importance to him, through the years, of teachers' mutual support in identifying critical subtopics in the various courses. Another opportunity is provided by the math team, for which seven teachers, without pay, serve as coordinators and advisors. And finally, professional meetings provide this staff a stimulus for interacting. As noted above, Young, in particular, and Cabot stress the value of such meetings and 80 percent of the mathematics department respond by attending at least the state-level mathematics meetings each year.

Conclusion

Silver Valley is rich in factors contributing to the success of its mathematics program. The dominant one is leadership, in the persons of the principal and, especially, the department head. Their careful planning and management have produced an environment which both exalts and challenges the teachers. The teachers themselves constitute a second influential factor, through their knowledge, dedication, flexibility, classroom control, and enthusiasm. A third factor is the curriculum, carefully sculpted through the years and supported by an exemplary system of placement and monitoring. The resulting program is steeped in high expectations and a constant attention to accountability.

The long acquaintance with excellence is also a contributing factor of a sort -- the so-called "halo effect" -- which signifies that a tradition of success breeds pride, high expectations, and so more success. But for schools who want to learn from Silver Valley's success, citing the halo effect begs the issue. It is much more instructive to look at the quality that ties all of the above factors together and drives the tradition of excellence. That quality is consistency. It is a subtle quality that informs the entire program. For example, it leads parents to expect to be well-informed; it allows David, the student, to expect Mr. Tadisch always to make it possible for him to do well in class; it allows the teachers to expect a challenging review each time they are evaluated. That kind of consistency does not develop easily. It is the product of comprehensive planning and monitoring, and demands a constant commitment to honest self-criticism. Silver Valley exemplified it as well as any program we visited.

* * *

TAYLOR HIGH SCHOOL

A spirit of staff teamwork and collegiality pervades the mathematics program at Taylor High School, and it has led to a multifaceted approach to excellence. Students in the lowest-level courses get careful attention and innovative course material; minority students benefit from a vibrant supplementary pre-engineering program; the staff make a conscious effort to keep girls from dropping mathematics courses; indeed, the overall percentage of students taking 4 years of mathematics at Taylor is exceptionally high. There is extensive use of computers in the mathematics program at Taylor, including the use of teacher-developed geometry software. Leadership, from the district to the principal to the department head, is distinctive in its coordinated support and vision.

Taylor High School is Huron High School in Ann Arbor, Michigan.

TAYLOR HIGH SCHOOL

> "Most of the teachers in this school pull and gnaw and are fiercely independent. But even in that group, the math people stand out because they have a lot of pride, and they work exceptionally hard. I know of at least 3 who work 70 hours a week . . . There is a negative side, though, because burnout poses a real threat to our mathematics department."
> The principal, Taylor High School.

As we moved from school to school in our study, we mapped a variety of routes to excellence in mathematics. We saw no easy routes, of course, but we did mark some safe ones -- stick to the text, watch test results carefully, do what others do, but do it better. A second group of exemplary programs challenge their top students with the nontraditional, but keep to a traditional, though still demanding course with average and below average students. A few others are innovative with all their students, controlling risk with a basic reliance on traditional textbooks but incorporating the nontraditional where they see the need and can grab the opportunity.

Taylor High School fits into this last category. The teachers have committed themselves to frequent and meaningful computer use in every course; they have bolstered their commitment to excellence with an innovative extracurricular program for minority students; and they have made a conscious effort to keep girls from dropping out of mathematics courses. As Taylor's principal notes, the demands of innovation in the program have been severe. The strain of the staff's hard work shows through the gleam in the program, yet it is impossible to imagine the gleam without just that kind of effort. It is also difficult to imagine the program as imaginative and successful as it is without the support the Taylor mathematics teachers have drawn from the school and district administrators. In her letter of application to our study, the department head cited the support of "our mathematics coordinator, principal, director of secondary education, associate superintendent for curriculum and instruction, and school board" in securing funds for an expanded program in computer use. Her example not only outlines the chain of support for the mathematics program but also indicates the breadth of attention it has earned.

Taylor High School is one of three high schools serving a Midwestern city (population 105,000) much of whose character is molded by the large state university located there. Taylor comprises grades 10-12, and its 1,700 students represent a cross-section of the city's population -- many children of university staff, but many others with no univeristy affiliation at all. Twenty percent of the students are black; another ten percent are from other minority groups.

The physical design of the school is distinctive. Set on an open rolling expanse next to a small river, the round school buildings blend nicely into their surroundings. They were also given the round shape, I was told, so that students and teachers emerging from class would be spared the sight of waves of bodies surging toward them. As the student population grew, however, aesthetic concerns were set aside, and several mobile units -- so-called portable classrooms -- were installed on the grounds. They are still used, complete with portable heaters and leaky acoustics, yet in the advanced placement calculus course I observed, the close environment added an air of intimacy to an already congenial group of learners.

Congeniality abounded in the mathematics program at Taylor High School. The staff -- principal, assistant principal, and teachers -- were remarkably cooperative, thoughtful, and informative. And, when I asked to talk with a couple of students -- meaning exactly two -- the department head sent out the word and twenty appeared in the appointed room during their free period, eager to express their opinions about the program.

The attitudes of Taylor's staff and students reflect those of the surrounding community. The imposing proximity of a large and very good university puts education -- and mathematics education in particular -- on the front burner of interest for many residents of the city. Parents were termed "very interested and very aggressive" by the department head, Barbara Schmidt, who also characterized the community as: "very supportive: they have never turned down a tax millage." It would be a mistake, however, to write off Taylor's success in mathematics to its sophisticated setting and the interest of its constituents. The other large high school in the city has a student population similar to Taylor's, yet their mathematics results are not on a par with Taylor's, and their drive to be innovative lags far behind. As one of the district administrators told me: "The staff at Taylor pushed us on computers. We've had to push the staff at the other school."

All the same, while the community's interest in education hasn't assured Taylor's success in mathematics, it hasn't hurt, either. And while it seems evident that the mathematics department succeeds in good measure because "they pull and they gnaw," to use the principal's phrase, it is also evident that they find it inviting to pull and gnaw in a community where education is a commodity large and visible enough to grab onto. During my visit in November 1983, there was circulating in the community a 78-page document called "Proposals for High School Improvement" which, among many recommendations, called for raising the mathematics course requirement from 1 credit to 3 credits.

The debate in the community over the document was intense, and at times stormy, as group after group offered their opinions. "We have to ask for input from every community group," the director of secondary education told me, and so Cluster Meetings were held with various parent groups, the Rotary Club, the NAACP, and so on. Adding spice to the debate was the community's unsympathetic response to the teachers' strike which delayed that year's opening of school by three weeks.

There is another, somewhat conflicting side to the community, as well. In spite of signs of community interest in education, the group of seven girls from AP calculus whom I interviewed complained that there is too little attention paid to academic excellence by Taylor students. They felt scorned for their AP ties and resented the annual "Geek Week" in which participating Taylor students don glasses and carry armfuls of books around the school. And in spite of the presence and influence of the university, the mathematics department head told me that the department doesn't use or interact with the university "nearly as much as we should." Indeed, except for the engineering program for minority students described in a later section, I saw no evidence that contradicted her.

The apparent conflict here -- community intensity about education versus some insouciance at the school -- resolved itself for me as I got to know the students and teachers better. The former -- in particular, the AP girls -- are very serious and their standards are high; the latter are exceptionally confident and independent.

When we chose our exemplary sites to visit, we were attracted to Taylor for several reasons. Certainly the efforts to attend to equity in mathematics education were attractive, and the moderate success of those efforts made the school even more attractive. Although girls represented less than a third of the advanced placement calculus class I observed, they represented half of the students in the non-AP honors calculus. We were also impressed that, despite the current minimum requirement of only 1 course, the staff has been able to enroll 75 to 80 percent of the students in mathematics courses each semester. Furthermore, AP calculus test scores and the percentage of students taking them have been well above national averages. And finally, we found Taylor's extensive and innovative use of computers very appealing.

The support that underlies the computer use at Taylor is worth mentioning here because it again illustrates how much and how widely the community -- in this case, the school board -- thinks about education. The Board has supported computer inservice for teachers, the summer development of computer materials by staff, and the purchase of a relatively large collection of hardware -- a few TRS-80's, 6 Itel time-sharing units, 22 Apples in the mathematics department, and another 24 Apples for word processing. In a community as complex as Taylor's, however, no such arrangement can be without its drawbacks and criticism. Indeed, the school's computer coordinator is of the strong opinion that the Board limited its generosity to hardware and has gone stingy with software and support needs. Consequently, he worried that the mathematics teachers, who bear most of the computer responsibility in the school, would get swamped and demoralized by their growing computer demands.

It would be a mistake to discount the computer coordinator's concern about demoralization. It would also be a mistake, however, to discount the enthusiasm that drives the mathematics teachers' sense of adventure and exploration as they set about changing the curriculum in some innovative ways. In a structure as rigid as the American public high school, a sustained spirit of exploration requires the support of enlightened leadership, which exists for the mathematics teachers at Taylor on three levels: the department head, the principal, and the district's director of secondary education.

The department head, Mrs. Schmidt, has been teaching mathematics at Taylor High since the school began in 1969, and she has chaired the department for a dozen years. Compared with department structures at other schools we visited, the arrangement at Taylor seemed better than average in its compensation of the department head. For example, Schmidt had a reduced teaching load of four courses instead of five, and was earning ten percent over what her salary would be as a fulltime teacher. Her authority to evaluate teachers is minimal -- by design, since at Taylor that responsibility belongs to the counselors, the three assistant principals, and the principal. Even so, as was the case with most of the good leaders we observed in this study, Mrs. Schmidt's influence over her teachers seemed in no way diminished by a lack of official authority.

The computer coordinator -- a physics teacher and so a close but still outside observer of the mathematics program -- spoke admiringly of Mrs. Schmidt's abilities to "rein in the divergent personalities in the department" and "to use what power she has as a lever to control the department." The image he offered was one of firmness, not rigidity, a critical distinction for those who would foster growth among those they lead. That Schmidt has kept this distinction sharp was confirmed by two mathematics teachers who characterized her sharing of materials as "a model for the rest of the department," and her willingness to "explain difficult things to the staff in several different ways," as a model in communicating.

Modeling of successful teaching behaviors is a characteristic of mathematics leaders we observed in this study, and so is the ability to engender trust. I heard evidence of the latter from several teachers regarding Mrs. Schmidt, but the most poignant example came from the seven girls in AP calculus. Almost all of them were enrolled in other AP courses as well, and they spoke fervidly of the pressure of their work loads. "Mrs. Schmidt," they told me, "is the only AP teacher who doesn't act as if her course is the only one in the school. We can trust her to change test dates if our other courses get too demanding."

I observed one incident that illustrated another aspect of Schmidt's qualities of leadership -- her willingness to listen. As I was chatting with her in the central area of the mathematics department, a teacher -- an exchange teacher from England -- walked in, glowering. Apparently he had endured nothing but trouble for the previous hour from one of his classes. As he fumed to us about their lack of respect and their lack of motivation, Mrs. Schmidt listened, showed she understood how he felt, and when he was ready to discuss options for dealing with the troublemakers the next time they acted badly, she helped him to talk through some options.

At the next level of leadership influencing the success of Taylor's mathematics program is the principal. His influence is primarily indirect, in that he pays close attention to the needs of the staff, worries about their morale, has taken some steps to alleviate their worries, and has taken other steps to continue from Mrs. Schmidt the line of trust that begins with the link from the staff to her. For example, when he saw the computer responsibilities of the mathematics staff growing to worrisome proportions, he gave the position of computer coordinator to a physics teacher. He told me that he takes pains to involve Mrs. Schmidt and the other department heads as much as possible in the interviewing of prospective teachers. When he recently became convinced that the district administration was giving short shrift to his staff in the development of the Proposals for High School Improvement, he, in his own words, "put my job on the line" to induce the administration to bring Taylor's department heads into the process of developing the proposals.

Despite some differences of opinion and strained feelings between Taylor High School and the district administration over the Proposals for High School Improvement, there is a third and very important level of leadership that influences Taylor's mathematics program, and it emanates from the central office in the person of the director of secondary education, Sarah Falco.

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Until the previous year, she had been the district's mathematics coordinator, and her stamp of personal interest and enthusiastic support has been on Taylor's exploration with computers from the start. More than that, she has explored with Taylor's staff some of the far-reaching implications of their commitment to integrate computer use into all courses. For example, she is intrigued by the prospect that the strategy might serve to ease girls into computer use, thus avoiding some of the male-dominated patterns that have emerged when other schools have begun computer courses.

Falco's commitment to sex equity runs even deeper. She has brought nationally recognized experts like Judith Jacobs to the community to speak with the teachers about women and mathematics, and she was instrumental in including in the Proposals for High School Improvement a provision that teachers will be evaluated on their effectiveness with women and minorities. Success with young women in mathematics has been real at Taylor High School and it is growing, yet the school, and the whole district, has so far failed to equal that success with minorities. The failure was clearly a sore point and source of frustration for Falco and, though she intended to target some efforts at the lower grades, since many of the minority students have already fallen way behind by the time they reach high school, her sense of frustration was still there.

Yet her frustration, like the principal's concern for the stake his teachers have in the future of Taylor, seemed a powerful and potentially creative emotion, and it promised changes for the better. The power in such feelings exemplifies the intensity of vision which guides the leadership -- at all three levels -- behind the excellence in mathematics at Taylor High School. Rarely in my travels to exemplary programs did I witness the quality of visionary leadership that I saw in the mathematics department at Taylor High School.

Of course, visionary leadership in mathematics is worth little unless the teachers also buy into the vision and apply it to their teaching. That Taylor's mathematics teachers share in the vision and associated commitment was evident in their pride and penchant for hard work. In particular, they are committed to weaving computer use into the entire curriculum, to adjusting curriculum materials to meet student needs at all levels, and to attending to the success of females and minorities. It was not the case that every teacher I interviewed is driven by each of these, but each goal has its own group of passionate advocates among the staff, and the aggregate of harmonious passions defines a unified staff commitment. Furthermore, all of the teachers are determined to look beyond the text to meet their goals. There is a deep-rooted tradition in the department of developing supplementary materials and, as one veteran teacher described it, "Whenever a new text comes, we adapt our materials."

This particular veteran, Mr. Weston, has been supplementing the geometry curriculum with logic activities since the school began in 1969. With district support during the summer, he has developed computer-related proofs to supplement the geometry text, and he and several colleagues have been honing the computer materials into a five-day component for each of the geometry courses. The activities are well-conceived in their use of the computer. For example, one of them challenges students to induce a formula for the circumference of a circle by letting the computer crunch out the

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computations for the perimeters of a sequence of polygons, the numbers of whose sides increase so they approximate the shape of a circle. Weston sees the computer as "a way to weave geometry, algebra, and logic throughout the curriculum," and he is clearly inspired by that prospect.

I saw the computer being used in other contexts: in the math lab, where 16 low-level students worked individually with the Milliken Company's basic skills software; in a precalculus course in which several students stepped to the microcomputer at the side of the room to write a brief BASIC program to help compute some limits of numerical sequences. In career math, which is a course many of the math lab students move into in eleventh or twelfth grade, the teacher assigns her students several very simple BASIC programs -- e.g., to change units of measure. (She also uses calculators with them for some problem-solving activities). Each of these uses came from the teacher's own initiative. Indeed, all of Taylor's computer materials are written by the mathematics teachers.

Though textbooks are chosen by a district-wide committee, Taylor teachers have something to say about their use. For example, they insist on using the same texts for different levels of the same course. Thus, all levels of geometry -- from honors down to the lowest level -- were using the same text, with the demands of the courses differing in the amount of material covered and, to some extent, in the depth in which it is covered. Tests, too, were fairly standardized across levels and were developed by the teams of teachers assigned to a particular course. I was told that the staff avoided curving for grades and aimed as much as possible to grade on the basis of ideas understood, even if it means that no A's are awarded for a particular test.

As in our visits to other schools in this study, I watched for any direct or indirect expressions of high expectations to students that might bear on the success of the program. The firmness in the standards of Taylor's staff, permeating all levels of courses, was one of the broadest indirect expressions we saw in our study. In order for such firmness to work, however, it must be balanced by careful attention to student placement, and then to meeting the needs of students, once placed. With some slight wavering, the balance appeared to be in place in Taylor's program. In the tenth grade there is one honors level, which thereafter splits in two -- one being an AP track. There is a regular college track and, for the incoming tenth graders with the lowest skills (and some eleventh graders), two courses are available: essential math and math lab. I was impressed with the care and thoughtfulness of the young teacher who teaches both of these courses. The essential math students make use of a text, while the math lab students don't, so she was developing her own diagnostic test to assist her in placing the students with low reading skills in the math lab course.

There was wavering in the balance, however, and it comes from the preponderance of black students in this lowest level -- nearly 60 percent of black students are in those courses. Two of the black teachers I interviewed see the problem's roots in the junior high: "At least one junior high in the city begins tracking in the seventh grade, and many black students are eliminated long before we get them." For the black students who do survive, these two teachers have begun a cooperative program with the local university's engineering school. Once a week, about 20 black juniors and seniors meet during their lunch hour to work on projects such as building a microcomputer, to go on field trips, or to listen to invited speakers -- usually black engineers. In addition, during the summer, the university arranges summer jobs for the students with support from one of the state's largest companies.

To make the program work, both teachers actively recruit when the school year begins, taking time in staff meetings to canvass other mathematics teachers for sophomore candidates. They then approach the recommended students with blandishments like, "You're doing well. Why don't you come to our next meeting." The effort is simple and persuasive, and it evidently pays off. All of the students who have stayed with the club through their senior year have gone on to four-year colleges.

As successful as the club has been in motivating black students who show potential, there were no blacks in the AP calculus course I observed, and the majority were progressing no higher than the lowest track. If the present Proposals for High School Improvement hold up, all teachers will be evaluated on "success with females and minorities." This should keep the efforts at improvement alive, but those efforts will have to be considerable.

The influence of the surrounding community, the firm and supportive chain of leadership, and the imaginative curriculum all lend strength to the mathematics program at Taylor High School, but it is the quality of teaching in the program that makes it vibrate with excitement. And it vibrates, rather than merely hums, because the quality has several layers to it. The teachers are bright, with the brightness revealing itself in planning, organization, and follow-through. The teachers are enthusiastic, and they feed that enthusiasm to each other. And, lastly, the teachers are guided by a deep sense of responsibility -- to their students and to their own ideals -- and they reveal that quality by the long hours they put in.

When we visited, there were 13 mathematics teachers in the department (2 part-time), 5 of whom had been on the staff for more than 10 years, 5 of whom had been on the staff between 5 and 10 years, and 3 who joined in the past few years. (One was a Fulbright Exchange Teacher from England.) Their offices, which they share in pairs, all open into a central meeting area which is decked out with bulletin boards, blackboards, shelves of books and journals, and tables. Students are free to come to this area, and during the two days of my visit, there seemed always to be something going on in the area -- usually students meeting with each other or with teachers. When I remarked on the constant use of the meeting area to Mrs. Schmidt, the department head, she beamed at my having recognized something very important to her: "Oh, yes. We are a staff working together toward a goal." The goal, of course, is the continued excellence of the program, from the lowest level to the highest level,
and the meeting area helps to keep the striving alive by making teachers more available to students. It also allows them to nurture the spirited collegiality I found so attractive about this group of teachers. The area often resounded with laughter and lively discussion, and its bulletin board, which contained announcements, short articles, and puzzles (put there by teachers to challenge their colleagues) seemed a useful and well-used mechanism for communication.

The collegiality extends beyond the meeting area as well: all teachers within the same course work together to develop final exams. One teacher told me: "The teachers in this department automatically put copies of tests they use in each other's mailboxes." And the physics teacher/computer coordinator told me that mathematics is the only department in Taylor High School "where, within courses, things are tightly coordinated. Each teacher is insistent that the topics he or she thinks are important are covered by the other teachers."

The computer has also become a vehicle for nurturing collegiality, with the exchange of opinions, ideas, and materials it demands, but the cost has been dear. Schmidt acknowledged that her teachers "have invested many additional hours preparing computer materials, grading projects, and keeping the computer lab open for students' use after school and at other times." The former computer coordinator, Arthur Elkins, who pioneered the use of computers at Taylor and was still teaching the advanced computer courses, told me he spends at least two hours a night grading programs. Mr. Weston was paid for two weeks' work during the summer to develop his geometry computer materials; yet he estimates he spent more than 200 hours on the project. Although the principal has tried to alleviate some of the computer burden of the mathematics staff by involving the physics teacher as a coordinator, the burden and strain remain, and they will continue to test the mettle of the mathematics staff for some time.

The characterization of the mathematics teachers as organized and consistent in their follow-through comes from perhaps the best source of all on the subject -- the students. When I met with a group of them and asked what made the math program special, they agreed unanimously that the mathematics staff was the most organized of all in the school. A transfer student then spoke up to contrast the Taylor teachers with the mathematics teachers in his former high school: "Where I used to go to school, we just went over our homework in class, then moved on to new homework assignments. Here at Taylor, teachers lay things out so we can understand them."

They can "lay things out" as well as they do, apparently, because they approach teaching very thoughtfully. The woman who teaches math lab, essential math, and career math -- the lowest level courses -- impressed me with her dedication, determination, but especially her resourcefulness, taking frequent opportunities to supplement text work with calculator, problem-solving, and computer work. The two teachers who coordinate the extracurricular engineering program think carefully about involving black students in mathematics. The quality in Mrs. Schmidt's teaching was recently acknowledged offically when she was named her state's winner of the Presidential Award as outstanding mathematics teacher. But the story that sold me on the teachers' reflective approach to mathematics teaching was related by Weston. One of his students showed his father the logic materials developed by Weston and the other geometry teachers to supplement the geometry textbook. The father, a teacher of logic at the university, found fault with the lessons and passed on his criticisms to Weston. I asked Weston if the criticisms had been difficult to hear, if he had wished that the father had minded his own business. He seemed honestly put off by the question: "Oh, no. We took the criticism very seriously and analyzed our materials to see if the criticism was valid. It was, and we made changes. We actually were grateful for the help." Here, I realized, is the essence of confident and reflective teaching: the ability to listen to, analyze, and use a critic's suggestions.

The enthusiastic teaching and the preparation, organization and thoughtfulness I observed among Taylor's mathematics teachers were all first rate, but there was one gap, one level of excellence they have yet to reach. I saw little of the kind of higher order classroom interactions we observed at such schools as Trinity High School and East High School -- the approach to teaching that aspires to developing mathematical thinking as well as inspiring the learning of mathematics; the classroom questioning that challenges students to analyze their own thinking, refine their explanations, and ask good questions. These were generally missing at Taylor, but they constitute a perspective and a set of skills that are easily within the reach of the Taylor teachers I met. Perhaps they lie on the next plateau of excellence toward which they will push the program.

Summary

Taylor High School is proving that innovation and success can proceed hand in hand. Their success in mathematics has a bit of the traditional in it -- namely, high AP calculus test scores and a high percentage of students in mathematic courses; it has a bit of the nontraditional in it as well -- an innovative plan for computer use and a supplementary program to attract black students to technological majors in college. Underlying the program's excellence are a staff that is extraordinarily reflective in its approaches to teaching and curriculum design, and a chain of leadership that makes excellent use of the conscientious and energetic staff, taking pains that they be involved in decisions about the future course of mathematics education in the school and district. It is a tightly woven program with a singular focus on excellence.

* * *

GREELEY HIGH SCHOOL

Greeley High School is an urban magnet school for college bound students. Its mathematics program has incorporated the International Baccalaureate Program for the top courses, and is distinguished throughout by a cohesive, sharing staff of teachers whose time commitment to the program is exceptional. Leadership has played a role in the program's success -- the department head acts consistently in support of her teachers and the principal and higher administrators have given the program the underpinnings it has needed. With over 50 feeder schools, the program faces considerable challenges for continued responsiveness to student needs, and for the staff's desires to keep expectations high.

Greeley High School is Rufus King High School in Milwaukee, Wisconsin.

GREELEY HIGH SCHOOL

> "What makes the mathematics program so strong? The teachers -- they have a sense of mission."
>
> Former Greeley principal, now Assistant Superintendent

In one form or another, a sense of mission seems to inspire many successful mathematics programs. It certainly was not uncommon among the 28 schools we visited in our study. It would be difficult, however, to point to a program whose sense of mission is more idealistic, intense, and even adventuresome than at Greeley High School.

Greeley has been designed to provide excellence with equity, not just in the hollow, hopeful tones of most program designs, but with clearly delineated standards. In the duality of the goal, it seems an especially American experiment. At least it is difficult to imagine another country's educational system supporting the struggles and risks that have shaped the first few years of Greeley's existence.

Greeley is located in a large Midwestern city (population approximately 600,000). Six years before our visit in October of 1983, the courts ordered the city to make efforts toward school desegregation. In response, the district decided to set up a series of magnet schools, including Greeley High School as the designated "high school for the college bound." Before the transformation, Greeley had been almost entirely a minority school, with the worst reputation in the district for crime, drugs, and disruption. As a special school, Greeley was completely transformed. The staff and students were transferred out, unless they qualified for the new Greeley and wanted to stay. For staff, the requirement for staying was a master's degree in the subject area being taught or 15 hours beyond a bachelor's degree, including a subject area research course. Students were required to have a C average, and the racial mixture of the student population was set to match the city's -- approximately 60 percent white, 40 percent black.

With the luxury of a clean slate, the designers of the new Greeley High School were ambitious in laying down their expectations and standards, and they have been tenacious in holding onto them. From the start, the staff has aimed to qualify 90 percent of the school's graduates for college, and they continue to meet their goal. Attendance, carefully monitored, has been an ongoing measure of success, and the average daily attendance is 95 percent. Academic standards were raised above those of other high schools in Greeley's district. For example, students are required to take a minimum of two years of mathematics, and are required to begin with algebra, unless they have had it before they enter Greeley.

The commitment to the city has been strong; as Greeley has become popular, the suburbs have been attracted to the school but have been allowed to account for not more than 10 percent of the students accepted. No such limit on students was necessary in the first year, however, when both city and suburbs were chary of the new special school and its sense of mission. The first principal -- now assistant superintendent in the district -- advertised, hustled, and cajoled, spending evenings, along with his staff members, at neighborhood meetings throughout the city to convince wary parents that enrolling their children in Greeley was worth the risk. The school started small; since then, the growth has been rapid. From a first group which numbered just under 300, the school has grown yearly to 530, then 700, 830, 900, and finally to 1,100 in 1983-84. The original goal for the school was 1,000; so size, with all of its challenges to teachers and administrators, has suddenly become an issue at Greeley High School.

Early on, when the agenda for change was still taking shape, the school decided to adopt the Geneva-based International Baccalaureate (IB) program, which allows juniors and seniors to earn credentials for college course credit or advanced placement at universities. Greeley's mathematics department has designed its precalculus, calculus, and advanced topics courses according to IB standards. There are three levels of IB exams, and the numbers of Greeley students taking one of the mathematics exams have been increasing. In 1983, 25 took one of the mathematics exams; 30 took a computer studies exam. In the year of our visit, the staff expected 50 students to take one of the mathematics exams and about 25 or 30 to take the computer exam. Adoption of the IB program was but one manifestation of the daring that inspired the transformation of Greeley High School. In mathematics, at least, the adoption has not been without problems as we shall see, but the increasing enthusiasm of the students for advanced college placement speaks well for risks taken.

We were attracted to Greeley by the daring in their experiment as well as by their accomplishments. On the so-called Subsidiary Level of the IB mathematics exams, the exam most frequently taken by Greeley students, the Greeley average in the two years spanning 1981-83 was about 4.7 (out of a possible 7); the international average was about 4.2. Furthermore, the 1983 average of the 8 Greeley students who took exams at the other 2 levels was 6.0, well above the international average. In addition, Greeley's student interest in extracurricular mathematics activities has been high, and Greeley's contest achievements have been impressive.

To the two of us who spent two and one half days at Greeley, this penchant for forging ahead, taking some risks, and aiming for ideals seemed to us the most exciting aspect of the mathematics program, and indeed, of the entire school program. The commitment to equity, the endorsement of a "nothing lower than algebra" curriculum, the embracing of the IB program, the plunge into new computer competitions and a welter of mathematics competitions, all seemed very exciting, especially in light of the record of success.

A specialized school like Greeley is bound to have several strong departments, but the mathematics department there seemed to stand out. The principal noted that, in what he described as a "very strong teachers' union town," the mathematics people appeared to stay later than others to help students. ("I never see a math person leave at 2:45, the time beyond which we can't make them stay.") The school coordinator of the IB program told us, "Of all the departments, mathematics has come the closest to meeting the needs of the gifted." The assistant principal, who handles scheduling, reported that "the requests for increased mathematics courses and staff members have been one quarter higher than in other departments."

From the first years of trying to sell the school idea to the community, the mathematics department and, indeed the whole school, have cultivated parent contact carefully. A Parent Day took place during our visit and we were able to observe interactions and to interview parents. The school uses a clever strategy -- having parents come in to pick up report cards. Artificial though the strategy is, the school makes full use of it to build parent-teacher communication. The entire staff -- teachers, guidance staff, and administrators -- seat themselves throughout the cafeteria and a steady stream of parents sit and talk with them. Despite the daytime scheduling for the event, the turnout was very impressive and, as we watched them, the conversations seemed long and substantial. The year before our visit, with just over 900 students in the school, 800 parents showed up for at least one Parent Day including many with children in trouble with grades, a noteworthy accomplishment. At Greeley, if any special contact is needed later on, the bridge has been established at the Parent Days. For example, when asked about any efforts toward ensuring minority success in the IB courses, the principal described how he had recently been on the phone with the mother of one minority student who was late in submitting an IB essay. He and the mother established guidelines for seeing the student through the task -- the principal to watch the guidelines at school, the mother to watch them at home.

Despite its special history and the care taken in its development, Greeley High School was for us another example of a successful school struggling for support within a large urban school system. We had noted in other city programs in our study that success can seem a liability in a system where large-scale politics control decisions, and where politically savvy administrators are disinclined to favor one school or program over another. In that kind of environment, successful schools and programs often earn little more than benign neglect; compliments flow freely, but real support flows to the schools and programs that need shoring up. The situation in Greeley's district is not quite so dire, but administrative support for the school, and the mathematics program in particular, is mixed. As described above, the school could not have gotten off the ground without the salesmanship and leadership of the original principal, who now supports the program from his position as assistant superintendent. Also, after the district conducted a recent survey of mathematics teachers throughout the city, a set of recommendations was made, several of which are consistent with the goals of Greeley's mathematics program -- in particular, training in effective teaching models, such as the Missouri Mathematics Effectiveness Project, and allocations of overtime pay for teacher-sponsors of student participation in mathematics extracurricular activities.

Real financial support, however, lags behind ideals and recommendations. Although a concession was made by the district in allowing small IB classes, there is a strong commitment not to treat Greeley differently from other schools. That means, in particular, that the mathematics department proceeds on a very skimpy budget. (Little money is available for materials, and students buy their own textbooks.) The department head reported having to do some arm-twisting with the principal during the year's budgetary wrangle to make sure that computer supplies were not drawn from her budget. The school itself seems to have done little courting of support beyond the district office. Though several administrators and teachers agreed with us that two large nearby universities could be easily tapped for tutorial help and supplementary programs, especially now that Greeley has expanded beyond the original goal of 1,000 students, we sensed no real desire to use the universities in this way. In light of the growing alarm among the mathematics teachers that many incoming students are being poorly served in large algebra I classes, we found the hesitation curious, if not a bit unsettling.

There were two kinds of leadership that attracted our attention in the study: the leadership that defines the standards of excellence in mathematics education and charts the course for attaining it, and the leadership that holds the course and cultivates the team effort that is essential for continued excellence and improvement. Often, as is the case at Greeley High School, the leader or leaders of the second type are different from the leader in the first type. In Greeley's case, Paul Atkins, the former principal and now assistant superintendent, took complete charge of the school's destiny in the first few years. By his own description, he left a deep impression all the way down to the classroom: "I was so damned autocratic, I gave teachers a format for class instruction and told them this was the way I expected them to teach. First thing every day, they were to review what was done the previous day. Next, I wanted them to outline for the class what was going to be done that day. Then they were to teach the lesson, summarize, and give a homework assignment. I wanted them to allow plenty of time to talk about the assignment, but absolutely no homework was to be done in class. I required each teacher to have a lesson plan and bring it to me when I visited his or her classroom. I came on very strong to teachers, but we were under pressure to make the school a success."

Now that the school is perceived as a success, and the individual departments have been able to mature in that success, the current principal, Peter Jackson, has been inclined to trust the departments to maintain their own standards of success. His own involvement in Greeley's classroom activities was embodied in good part in his commitment to building student questioning skills: "It takes time for some teachers who transfer to Greeley not to interpret student questions as disrespectful. However, I keep telling kids that there is no question too stupid to ask." Much of Jackson's attention goes to cultivating the image of the school in the community, for despite its record of excellence, the school continues to be scrutinized for its efforts at equity. "I tell my staff to be very careful about bringing non-integrated groups outside of school. I took a lot of flak recently for a non-integrated math team that represented us in a tournament".

At first glance, the stamp of leadership within the mathematics department was not evident. Indeed, after a few interviews it seemed to us the department was run as a cohesive group effort. Eight teachers were involved in mathematics team activities; they discussed courses together, and they even socialized together. And yet, as our visit progressed, it became apparent that the cohesiveness and vibrance we noted in the mathematics department were due in good part to the efforts of Mary Wallace, the woman who became department head the year after the school's transformation. There were some direct measures such as the monthly meetings and her ensuring that honors courses are rotated among staff members, but her leadership can be best characterized as a subtle fostering of trust and mutual respect among the members of the department.

Mrs. Wallace was an enthusiastic proponent of the IB program, sharing the teaching of the IB precalculus, calculus, and advanced topics with another woman in the department, Betty Ramirez. By their own testimony, both have had to work very hard to prepare themselves for the IB curriculum, especially advanced topics. "For awhile, we were learning along with the students," says Mrs. Ramirez. Both women have also stayed tuned to the issues of mathematics avoidance and anxiety, with one or the other teaching honors algebra each year as a means of identifying and encouraging mathematically talented young women. In addition, Wallace completed a mathematics anxiety and avoidance project for the district, resulting in a set of guidelines for classroom mathematics instruction.

As noted in many of these case studies, we are convinced that teamwork, a partnership of professionals working together, is an essential part of many exemplary mathematics programs. Often hidden in the team process are the quiet efforts of the department head to create and maintain an environment in which teachers are both challenged and able to act in a professional manner. In her conversations with us and in the interactions in which we observed her, Mrs. Wallace showed warm regard and genuine respect for her staff members, and she obviously valued their opinions in both formal and informal departmental meetings.

Given his looming presence in the design of Greeley, Atkins obviously left his stamp on the curriculum adopted for the school, yet he credited the staff with the bulk of its formation: "We gave the staff members no free time to develop the curriculum, but they did it." We noticed elsewhere that staff members' sense of ownership of curricula often goes hand in hand with excellence, and that process apparently helped to bring Greeley quickly to success.

At the upper end of the curriculum, as we have noted, the staff chose to design courses according to the International Baccalaureate model. In mathematics that model begins with precalculus, but the department staff members have committed themselves to the goal of informing the entire curriculum with the IB spirit, which takes shape in the following goals:

- to develop in students an understanding of mathematics as a discipline
- to develop in students attitudes favorable to later use of mathematics
- to develop in students the ability to learn mathematics on their own
- to encourage students lacking confidence in their own knowledge.

Greeley's record in attracting students to higher mathematics courses has not been as numerically impressive as the records of some other schools, but in light of its commitment to keep a 40 percent minority enrollment, and in light of the 2 to 1 female to male enrollment in the school, the record was impressive enough. At the time of our visit, it was the pattern that 80 percent of Greeley students took a third year of mathematics and nearly 70 percent took a fourth year. There are no non-academic mathematics courses in the curriculum, so the courses represented in these numbers are advanced algebra, precalculus, calculus, and advanced topics.

As surely as Greeley thrives because of its ideals and sense of mission, it also faces problems because of them. For example, the rapid growth of the school, combined with the commitment to the 60-40 racial mix, have led to a mild crisis in algebra I. With over 50 feeder schools, about one third of them private schools, Greeley has little control over the quality of prealgebra training. In another manifestation of the plight of urban programs caught in the politics as well as the large size of city systems, the guidance staff conceded that they know which feeder schools have the highest success rate for their graduates in Greeley's algebra I course, but they felt powerless to capitalize on the information. Instead, they were left with only one option, to recommend to incoming freshmen that they take a summer school prealgebra course. Compounding the problem further is the district's procedure for admitting students. If an applicant has a C average or better, he or she is placed in a pool according to race. There follows a lottery -- actually two, one black, one white -- by which students are selected according to the appropriate racial ratio. As the school grows, this procedure makes the mathematics department's task increasingly tougher, for while the large number of feeder schools make diagnosis for course placement in algebra I impossible, the school's commitment to high standards seems to have legislated against having a very active remediation program. High standards and remediation needn't be in conflict, but we didn't note any strong efforts to start such a program. Teachers regretted the termination of a federally-funded remedial resource center and wished that district funding could revive it. The assistant superintendent saw little chance of such funding, and remarked that it was his impression that Greeley was not doing enough to engage the help of local university students or to create a workable peer tutoring program. In the meantime, approximately 30 percent of Greeley students were failing algebra I on their first try. It was our impression that Greeley's mathematics department eventually will have to face the task of designing some kind of organized remediation if they are to keep their standards high.

Another detrimental consequence of rapid growth has been what teachers described as "the growing gap" between the honors and regular tracks -- that it has become very difficult, for example, for regular track students to succeed in precalculus, which is taught as an IB course. With only about 30 percent of the students in honors courses, the majority of Greeley students have been left, despite the school ideals about excelling, with few real options for advancement. Both the department head and the principal brought the problem to our attention, each identifying the move from advanced mathematics to precalculus as the weak link, so the opportunities for Greeley's non-honors students stood a good chance for improvement.

The school and mathematics department have employed several other strategies to ensure that the program moves ahead. Risk-taking is one of them. Despite its unexceptional computer setup (11 Apples in a room supervised by an aide, a computer concepts course and an IB computer course in Pascal), Greeley has forged ahead in computer competitions as it has forged ahead in other endeavors. Last year the school placed first in the Future Problem Solving Contest on Computers and entered 30 students in the first IB Computer Exam. (A total of 70 students took the exam internationally.)

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Another strategy has been to stay consistently firm with students (and staff) on expectations. At least a half hour of mathematics homework per night is expected. And no student is allowed to drop from honors until he or she spends at least a half-hour twice a week with a teacher outside of class to shore up whatever weak spots exist in the student's struggle with the honors curriculum.

Leadership and curriculum have obviously been influential factors in Greeley's success in mathematics. Staff qualifications also comprise an obvious strength of the Greeley mathematics department. There were 10 fulltime mathematics teachers and 1 combined science-mathematics teacher when we visited. Although they are a relatively young group (average age in the 30s), the minimum amount of teaching experience was 12 years. Three have taught at the junior high level and all but one of the eleven have taught at the college level (in the evenings).

In our staff interviews we were struck by how much the teachers all relished being at Greeley where, in the words of one, "we can concentrate on pedagogy and content, not discipline." Those who were among the original staff members when Greeley was transformed five years before our visit told of the ridicule they had faced from colleagues throughout the district for taking part in such a risky venture. All of the mathematics teachers talked of the open envy of those same colleagues now that Greeley has become a success.

They are a proud group of teachers, and they seem to have turned that pride into a healthy tool for maintaining good communication among themselves and for holding high standards in the program. The staff was meeting at least once a month with the department head; they were socializing quite a bit outside of school (conversations during a couple of our lunches with them were testimony to this); those who were teaching different sections of the same course planned together informally; and all took part in student mathematics extracurricular activities. Together they have been facing the problems related to the school's rapid growth, and shortly before we arrived they had voted as a group not to "water down" their advanced algebra-trigonometry course, despite the difficulties experienced by a growing number of students. Refusing to bend could create its own set of problems for the department, but in making their decision the staff took two steps that enriched their own investment in the excellence of their program: they reanalyzed and redefined their standards, and they did it together. Careful evaluation and teachers' ownership are cement for exemplary programs and such appeared to be the case for Greeley's mathematics teachers.

Both the principal and the staff members seemed to have defined carefully how mathematics ought to be taught at Greeley High School. The idea about teaching style and classroom questions seemed a bit tarnished, despite the principal's advocacy and the teachers' intentions. To be sure, in all the classes we observed, teachers made full use of the time available and kept students on task, and as in other exemplary programs we visited, the teachers maintained a giving attitude and risk-free environment in their classrooms. But only in several of the IB classes did we see much student questioning and prolonged student-teacher interactions. Even in an honors algebra I class, students quietly took notes and spoke only when spoken to. Furthermore, though this may be a luxury unreasonable to expect in a school struggling with change as Greeley is, we saw little of the in-class coaching and open expression of high expectations in teacher-student interactions (such as for consistent clarity in mathematical explanations) that we saw in other schools.

The involvement of Greeley staff and students in mathematical activities outside of the classroom was impressive. All of the ten fulltime mathematics teachers were participating in contest preparation and activities. During the 1982-83 school year, there were 82 students in the Math Track Club (whose name arises from the criteria used to award letters, similar to the criteria used by track clubs), and they participated in 25 mathematics contests during the year.

Summary

Among the joys we derived from visiting exemplary mathematics programs were the touching visual memories and tales of heroic endeavors which, while not bearing directly on the mathematics programs, helped to define the environments in which they thrived. At Greeley, we watched the principal beam as he unfurled the Banner of Excellence just awarded to the school by Secretary of Education Terrel Bell. We found it moving to listen to him relate the story of the anonymous staff member who donated $300 to cover college tuition costs for a gifted student who had exhausted Greeley's mathematics courses. We shared in the genuine enthusiam of the guidance counselor we interviewed, a veteran Greeley staff member who had coached wrestling and football before the transformation, as he informed us that never had participation and interest in sports at Greeley been so high as now, and that he and other staff members found themselves forcing students to leave the building in the evening, so eager are they to spend time with each other.

Greeley High School was born from ideals and thrives on innovations and a sense of mission. Partly because the school has been successful and was growing so quickly, reality was rapidly catching up to the ideals. Despite the sense of mission, the school remains a big city school with all the attendant problems -- tight budget, a sense of distance from the top levels of the district administration, and the intrusion of politics into education. Through it all, the mathematics department has had an enthusiastic, engaging, talented, and industrious group of teachers, and for us it was one of the most inspiring programs we visited.

* * *

EAST HIGH SCHOOL

East High School is a specialized public high school for talented students. Its long tradition of excellence, both locally and nationally recognized, does much to sustain the high expectations for excellence. Student interest in mathematics extends far beyond classroom walls, with daily meetings of the mathematics club and numerous extracurricular mathematics research projects. Teachers consistently communicate their high expectations in the classroom -- e.g., their expectations for clarity in students' mathematical argument. Also, teachers actively use coaching techniques in the classroom. The department head adds an extremely cohesive force in supporting teachers and obtaining necessary resources, often in the face of a daunting lack of bureaucratic response.

East High School is Stuyvesant High School in New York City.

EAST HIGH SCHOOL

> "We've been doing so well for so long that the district administration is reluctant to give us the funds to replace our decrepit equipment and to expand our computer facilities. To them, it's like the Yankees asking for more money."
>
> East High School mathematics department head.

East High School is a perennial contender for the nation's most prestigious mathematics prizes. As the chairman's remark illustrates, however, their success does not hinge on the quality or the quantity of East's educational materials. Quite the opposite. The word "decrepit" to describe East's computer facilities came originally from the district's computer coordinator, and according to one of the teachers of computer courses, several of his colleagues were ready to leave East because of the state of the equipment. Furthermore, two teachers bemoaned their having to carry erasers and chalk from classroom to classroom in order to effect a crisp beginning to their classes, free of the need to scrounge and search that apparently haunts those who are less prepared.

The resources East can and does rely on for success in mathematics are a superbly prepared and superbly able set of students, a highly qualified and industrious group of teachers, and a tradition of excellence that drives the pursuit of further excellence. All three are such evidently powerful factors that I visited East with the fear that little there can be adapted elsewhere. I now consider the fear unfounded; there are aspects of East's program that deserve the attention of all mathematics educators. In particular, the teachers' planned consistency in instruction, the pervasive insistence on high expectations, and their attention to how students "learn how to learn" all have ramifications far beyond programs which are tailored for talented students only.

East High School is a so-called specialized public school in a Northeastern metropolis, a comprehensive school which students enter through a very selective entrance examination. They represent the intellectual cream of the city's young people, and the quality shows. Throughout my two-day visit in November of 1983, I was impressed not only with the intelligence of the students, but also with their generally urbane spirit, confidence, and good humor. Their talents and interests are wide-ranging, as evidenced by their more than 70 extracurricular clubs and organizations, including the traditionally serious, like Chess Club and the Bio-Med Seminar Society, as well as the imaginative and frivolous, such as the Mad Scientists Club and the Sports Collectors' Memorabilia Club.

East, which serves approximately 2,500 students, is housed in a narrow five-story building, and the hourly flow of students and teachers up the up-staircases and down the down-staircases adds to the impressive energy level in the school. As in all the city's schools, the entranceway is monitored by uniformed guards, a precaution that, however necessary, seemed out of place because of the healthy and friendly energy in the hallways and the businesslike intensity in the classrooms.

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The energy and intensity are consistent with East's impressive record in mathematics: approximately 300-400 students a year in advanced placement calculus courses, with average scores well above the national averages in both the AB and BC advanced placement exams; 3 winners of Westinghouse Science prizes, all in mathematics, in the decade preceding my visit; and the highest ranking in the country more often than any other school in the previous decade in the American High School Mathematics Examination. SAT scores, extracurricular involvement, and upper-level course enrollments are all testimony to the exceptional accomplishments and enthusiasm of East's mathematics students. A beaming first-year teacher told me, "This place is like teaching at a college." Yes, I thought, but even better than college. These students have not yet begun to tighten up and take themselves too seriously.

I interviewed four students during my two days at East and, when they talked about the success of the mathematics program, they generally cited the teachers' behavior:

> "All the teachers let you know they expect you to put in a certain amount of work every night."
>
> "Miss Abrams is the best teacher I have. She's really demanding, but she doesn't get down on us if we don't understand or remember something."

The most informative of these students was a senior named Phil. Phil is a very bright student, even by East's standards, but in his style and opinions he typified many of the school's students. Cocky without offending, free in offering his opinions, he talked with me about several facets of the school. About his study habits: "When do I do homework? When I don't understand the topic it covers." "I try to use teachers' techniques to teach myself. For example, when I don't understand a use of notation, I see how the teacher worded its use in my notes. I translate the mathematics into English, and I try to come up with real-life examples and applications." About changes he would make in East's mathematics department: "I would have teachers doing more review; I'd try to make some of the teachers more lively; I'd let the better students occasionally depend on their notes and not come to class." About changes he would make in mathematics education: "There are too many short-answer questions on tests." Phil, who took algebra II and trigonometry in junior high school, takes a full load at East and two computer courses at a local university.

Another student talked with me about the excitement of being involved with the mathematics team. He was captain of the second team (the school competes with 2 teams), and told me that the team "works so well because it gets everyone involved." In an environment in which competitiveness and pressure could sour the students' experience, the team members have managed to minimize the pressure ("No one leans on you to do a problem you don't want to do.") and have sustained an atmosphere of enjoyment.

In order to watch the math team in action, I arrived at East at 8:00, an hour before classes begin, when the nearly 70 students who make up the A and B teams arrive every day of the week, some traveling on public transportation for an hour and a half. Robert Alpert, the team coach as well as department head, said that the session I watched was typical: the group divided into two smaller groups, juniors and seniors in one, freshmen and sophomores in the other. Both groups were run by students, one male, one female, who led discussions about problems just encountered in a surprise quiz, although the word "quiz" hardly fits, since judging from their enthusiasm, these young people apparently thrive on being challenged to stay sharp. As I watched the lively discussions, I thought about the shortsightedness of those who shrug off East's superb team record as simply what results when bright and motivated kids capitalize on their brightness. Obviously, the record is built on hard work and sacrifice as well as talent. And pride . . . Alpert told me that many team members stay in touch with each other after graduation, much the way champion sports team members do.

The students were evidently a major factor in East's mathematics success story, but it was equally evident to me that they were not the only factor. After all -- to borrow from Alpert's analogy -- the long record of success of the Yankees did not derive only from their wealth of talent. Other factors, among them leadership and style of play, enriched the team during its heyday. Leadership and especially teaching style also seem to be at work behind the tradition of success at East High.

The manifestations of leadership in East High School's mathematics program are not as clearly delineated as they were at some other programs we visited. Alpert, the chairman, though a teacher at East for 12 years, was in his first year as department head and so was still feeling his way. Much of his energy has gone into dealing with the school district administration. That monolith has ceased to be a direct positive force in the success of the program. Indeed, at several turns, Alpert has been frustrated in trying to shake some support out of the bureaucracy -- he has sent memos and proposals depicting the inadequate computer facilities, and continued to swallow his embarrassment in November at not being able to come up with the $2,000 for the double disk drives he needed for the new AP PASCAL course, and for which he is being dunned by the supplier who had delivered the drives in time for the beginning of the course in September.

Alpert was feeling keenly the frustration about the equipment: "We could easily put in more PASCAL sections if we had the equipment. We have to send some of our Westinghouse Project students to other schools in the district because our computers are insufficient for their needs. If I had it, I could spend $100,000 on computer equipment right now, and we would use it immediately and use it well." In the meantime, he does what he can. He has taken it upon himself to try to exploit contacts he has in the corporate business world for support and has written (still unanswered at thes time of my site visit) letters to state legislators describing the plight. Furthermore, he facititates the entry of his students into local college and university computer courses and arranges their use of computers at other high schools. He was looking everywhere for solutions.

Despite his frustration, the leader in Alpert was developing quickly, as evidenced by his cover-all-bases approach to getting his students' computer needs met. I marveled at the equanimity with which he dealt with the constant bustle in his office and with his being pulled in four or five directions at once. His office is tiny, with a slightly larger outer office, no secretary, and a seemingly constant flow of students and teachers filtering in and out.

In one brief span, I watched as he dealt with a student complaint about a veteran teacher, a telephoned parent complaint about a substitute teacher (to me: "Gee, we were lucky to get the guy -- he's certified. I'd better visit his class this afternoon."), a student asking a computer programming question, a teacher's question about textbooks, and the dunning disk-drive supplier. All the while, he was trying to help me get set for my next hour's activities as site visitor and somehow he managed to make me feel that I was not a burden. If two indicators of good leadership are an open door and a broad set of shoulders able to handle many demands at once, able to relieve staff members of bothersome distractions, then Alpert passed on both counts. The hubbub I witnessed, however, did not seem atypical, so I was left wondering how long his equanimity could hold up. Like many of the leaders we got to know through our study, Alpert works very, very hard, teaching four courses, administering the department (in all of the aforementioned ways), and evaluating staff ("I observe each of the 22 teachers at least once a year and write a report for each."). In addition, he has developed some commercial software and intends to write a textbook for the teaching of PASCAL.

In one other aspect, Alpert reminded us of other mathematics leaders -- in the way he was keeping an eye on measures of excellence. In East's case, since test scores and course particiption are so extraordinary, the barometer Alpert uses is the record of the math team, which he supervises. With a mixture of embarrassment and respect in his voice, he told me how East had been blindsided by a non-specialized high school last year, which took away the city championship. Clearly, the memory of defeat was a useful motivator for him and, I inferred, for his team members as well.

There were other manifestations at East High of enthusiasm for mathematics beyond the classroom. During my visit, every bulletin board in the school contained an invitation to attend an after-school lecture on problem-solving in geometry by a mathematician from one of the city's universities. The teacher in charge of such lectures (one occurs every couple of weeks) was confident that 200 students would attend. Time is a commodity the students (and teachers) are generous with when it comes to mathematics. In some cases, over 1,000 hours have been devoted to Westinghouse Science Competition mathematics projects by students. They receive regular staff guidance in their efforts, often from Alpert.

The guiding principle behind curriculum development in East High's mathematics program has been to provide the content that will meet the needs of their special student population, despite the implied burden this often puts on teachers to learn new material. Because both talent and experience are assumed for incoming students, most of the attention has been focused at the upper end. Two new courses were introduced in 1983, PASCAL and advanced calculus, and when I visited in November, Alpert was already talking about a new numerical analysis course for next term, if he could find someone to teach it ("though I may end up doing it myself"), and more PASCAL. In the recent past, the department has offered courses in number theory and the history of mathematics. For students who began the SSMCIS Unified Mathematics curriculum before entering East High, there was a Unified Mathematics curriculum strand in the program. The variety of mathematics courses was richer at East High than in any other program we visited. Even within East High, the variety stands out, as Alpert informed me that the mathematics department offered more courses than any department in the school.

East teachers use textbooks, but no teacher I observed seemed tied to the text. In the geometry class I visited, the teacher developed his own treatment of indirect proof. The honors precalculus teacher led a discussion about converting graphical representations of conic sections to equations; his students dutifully took notes during the discussion and, as several mentioned to me later, it would be their notes rather than the text that they would appeal to for their homework. One of the computer teachers told me that all of the computer courses were being taught from teacher notes rather than textbooks. The most challenging of these, of course, was Alpert's AP PASCAL course, one more layer of work in his prodigious set of tasks.

With all of its variety, sophisticated content, and teacher development beyond the texts, the mathematics program at East depends heavily on the self-motivation of its students and on the teachers' abilities to nurture and employ it. Most students enter East High in their freshman year; a smaller percentage of sophomore transfers are admitted every year, but no transfer students are admitted after sophomore year. There are no honors courses for first-year students; the honors program begins in second semester of the second year. East students are expected to pass the state achievement exam in intermediate algebra and trigonometry before they graduate, but that requirement puts little demand on most of the students. In a school that admits between 500 and 600 freshmen each year, there were but 3 sections of elementary algebra; the large majority have taken algebra in junior high school and get very quickly to intermediate algebra and trigonometry at East.

But what of the lower students, those who enter with no algebra or insufficient algebra in their background? I wondered how well they are served. I wondered in particular about minority students, since I saw so few non-Asian minority students in the honors and AP classes I observed. The evidence from interviews led me to no firm conclusions, but it seemed that the needs of the least mathematically talented and experienced students at East High get only part of the care they require. In an odd reversal of the typical situation, I heard more criticism on this issue from staff than from students. On the one hand, the students I interviewed, including a Jamaican immigrant student who was enrolled simultaneously in precalculus and calculus, thought that the reliance on self-motivation "works for 90 percent of the students," that "teachers are always available if you are willing to put in extra time," and that teachers are willing to arrange for tutors to help. On the other hand, I talked with two teachers who regretted the relative invisibility of the needier students. One, Frank Thompson, was an engaging, streetwise, and tough-talking veteran of the city's street academies, who was teaching the few elementary algebra sections at East. He believed that he was one of the few teachers, if not the only teacher, who checked homework regularly. He also arranged for a tutoring table in the cafeteria and gave extra credit to anyone who tutored. Thompson minced no words in his criticism of many of his colleagues. What many at East described as teacher reliance on student self-motivation, he characterized as the attitude, "If you can't do it, the hell with you. I'll see you on the way out the door." As hard as Thompson was on his colleagues regarding some aspects of the program, he was equally firm in his praise when I asked him why he thought the program was so distinguished: "There's a lot more teacher preparation here than in other schools I've been in. They put their hearts into it."

The other teacher, Mr. Carlton, new to East High and evidently nervous about being critical, talked with me about a blind spot he saw in the mathematics program: "We could be doing a lot more for the students here, especially in geometry. Of the 18 sections in geometry, only 1 is taught by someone who has been here more than one term. The more experienced teachers avoid geometry because it is such hard work -- all that writing of English sentences rather than equations on the board. But it is a tough course even for the bright kids. . . . Until geometry, math is all 'x = 7', not statements like 'a line perpendicular to a plane is perpendicular to all lines in the plane through its foot.' To take the attitude with all the students that 'You can do it; you're bright' just isn't fair."

It is difficult to determine how serious are the blind spots, both of a similar vein, described by Thompson and Carlton. Several students had remarked to me that students were aware that the better, "clearer" teachers were clustered in the upper and honors courses, yet they seemed not to feel that the phenomenon endangered anyone's learning at East High. It seemed to me, too, that the new teachers at East were a talented, enthusiastic group, eager to help their students succeed and excel. Certainly, that was the case with the first-year geometry teacher, Mr. Dunn. I watched him teach a class as dynamic and substantial as any class I observed in all my site visits.

Different schools in our study left us with different images. Mr. Dunn's class fixed the East High image for me, though it fit most of the classes I visited: involved students -- in particular, verbally involved students -- and blackboards full of mathematics, all around the room. If a full use of class time was a universal noticed in our study -- and it was -- then East High was the zenith. Dunn's class began with four or five volunteer students putting the previous night's homework on the blackboards in the back and on the side of the classroom. While they did so, Dunn led a discussion about information he had put on the board before class, some definitions and questions about indirect proof. After a while, he set a couple of volunteers to work at the board on an indirect proof while the seated students began work on a similar task. Eventually, he brought them all together for the remainder of the lesson on indirect proof and for a review of the homework. All the while, he kept peppering them with challenges like, "Copy down the statements of that: you should be able to put in reasons." "You should know this." "You should read that in . . ."

His blandishments and challenges were typical of most of the teachers I observed at East High School. The "you can do it; you're bright" attitude is not left unstated in the mathematics classrooms of East High. I did observe one class, a calculus class, in which such challenges had a sting to them, where the teacher's crustiness and almost military insistence on correct behavior gave an unfortunate slant to the high expectations -- e.g., "It never ceases to amaze me. I'm supposed to be teaching the brightest kids in the city and year after year, you don't know whether to add or subtract 'dy' to 'y.' And it makes me furious!" For the most part, however, East students and teachers seem to be able to keep their expectations free of threat and ill feeling and to make good use of them. The Unified Mathematics class I observed was a case in point. Mrs. Rosen, a tiny woman in her fifties or sixties, walked around the room and, like a debate coach or law school professor, challenged her 32 students -- mostly smiling students, by the way -- to keep their thoughts organized and their explanations sharp. "Who agrees with that?" "What would you have to do to prove it?" "You can give a better answer that that." I, too, smiled through most of the class, delighting in witnessing a stellar teaching performance. When I thanked Rosen afterwards, she apologized for not covering as much of the lesson as she intended. It is understandable, I thought, that so many students should smile during the class -- they know that Mrs. Rosen has as high expectations of herself as she does of them.

There were 23 teachers in East's mathematics department. Alpert, their chairman, had the only doctorate, but the vast majority have master's degrees plus 30 hours' further education in mathematics. Alpert characterized them as the hardest-working staff in the school, almost all self-taught in computers. "There isn't one who doesn't know his or her stuff." Their perquisites are meager, however. As I've noted, several felt obliged to carry chalk and erasers from classroom to classroom; there was a small lounge for teachers but no teacher offices or homerooms. Class size averaged 32 students in those I observed and, in several classes, a few students were obliged to sit on window sills.

I was impressed with the consistency in the instruction at East, not only the consistency in setting and expressing high expectations, but in the consistency of quality questioning ("How do we begin the analysis of this graph?" "What construction does this remind you of?"), and in the consistency of lesson organization. Several teachers whom I observed set the tone of their lessons with objectives written on the board at the beginning of class ("Aim: the hyperbola." "Aim: to find another way of proving statements.") Others had similar strategies, and the effect across the department seemed to be to keep students on a straight path. When they walk through the classroom door, the students know exactly what to expect from the teachers and what is expected of them. It is a compelling contract between students and teachers, by which the students produce regularly in homework and in classroom contributions and, as exemplified by Mrs. Rosen, East teachers maintain a style of teaching that openly combines maintaining high expectations for their students with maintaining high expectations for themselves.

Summary

Despite the inclination of some mathematics educators to dismiss East's achievements because "anyone could succeed with a student population like that," it is not difficult to envision a similar situation where the students would not be well served because the teachers had lost their sharpness and grown stale. The East teachers I watched and interviewed are well aware of the gifts they have been handed in their students, but I saw little taking them for granted. And I certainly saw scant stale teaching behavior. What I saw, and what other schools can learn from, was the consistency in the staff's expression of high expectations of their students, in their maintenance of high expectations for themselves, and in their course planning and challenging instruction.

* * *

JACKSON HIGH SCHOOL

Jackson High School actually ranges from grade 7 to grade 12, and is a school for talented students. The mathematics program is distinguished by the vision of the department head and the innovative teacher-developed curriculum that it has produced, from algebra through calculus. Courses and instruction in the department are further distinguished by their emphasis on understanding and mathematical thinking, as opposed to memorization and algorithmic learning. A premium is placed on noticing where mathematics can be applied in the real world. Recently, a second track has been implemented for students who have less aptitude for mathematics, and this presents new challenges.

JACKSON HIGH SCHOOL

> "Every community has a considerable number of gifted students, and very few communities have any honest programs for these gifted students. We are addressing an important national need."
> Mathematics department head, Jackson High School

Jackson High School is a small school for talented students with a tradition of excellence reflected in its alumni rolls, a list which boasts a couple of Nobel Prize winners and several famous authors. It is also a school in transition, and the strain of transition could undermine some of the qualities that have made it shine -- in particular, the exemplary mathematics program which drew us there for a visit.

Originally designed to be part of the college of education of a large Midwestern state university -- a laboratory gifted school for the training of teachers and the implementation of new ideas and new methods -- Jackson became semi-detached from the university several years ago. It is no longer part of the college of education, yet the university still maintains some control over the school. Indeed, a university faculty committee has spearheaded the program to give the school a new footing and new direction. At the time of my visit, a university mathematics professor had been named to be interim director on a half-time basis. Now financially independent from the university, the school has been able to pick up 60 percent of its operating budget from the state (a set-aside fund for laboratory schools). There is no tuition, so many parents have chipped in with donations (the norm is $1,000 per family) and 30 percent of the operating budget has been covered in this way. The remaining 10 percent is "scraped together," in the words of a parent, and the university helps with the building overhead. The distribution of these numbers speaks to the sense of some dislocation among its staff and supporters as Jackson restructures itself. It is a time during which staff, parents, and university faculty are asking basic questions about the school, such as: Do we stress acceleration over depth in our curriculum? Are we doing as much as we can to identify those students who require a slower pace and more direction? The nature of the questions is healthy; unfortunately, the processes used to generate and deal with them have not always been as healthy. Some of the university people and parents have been calling for changes and, at least in mathematics (the only program we visited), there were fears that their gains and the philosophy behind the gains would be jeopardized by the calls for change.

Jackson High School begins at the seventh grade and runs through the twelfth grade. The eighth grade is omitted, however, since it is felt that enough is covered in the seventh grade to consider the second year of the school the ninth grade. The students come to Jackson typically three years ahead of their peers throughout the county. Until recently, they have been accepted on the basis of a school-developed entrance exam, but the school found this unsuitable for non-English speaking applicants, and so moved to a nationally standardized test.

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By one teacher's estimate, about two-thirds of the students come from families where at least one parent is a university faculty member or is of similar professional standing -- doctors, lawyers, and so on. The school itself shows no special privilege, housed as it is in a brick and stone structure that would satisfy anyone's set of criteria for "the typical American school building." In part because the school underplays its role in keeping order and setting discipline, the student body as a whole seems almost undisciplined in its energy -- shouting and wrestling in the hallways between classes and joking in classes, especially in their opening moments. But these first impressions belie the real accomplishments of these youngsters and how seriously they take them. A closer listening in the hallways reveals how competitive many of the students are, reflected in the numerous conversations we picked up which centered on comparisions of test grades. And the mother of two students remarked, "It's a joy to hear so many intellectual conversations in the hallways. My daughters could never get that in the local public high school."

Interviews with a school graduate (now a computer science major in the neighboring university) and with four current students (one of whom was taking an advanced mathematics course in the university) provided a special student portrait of Jackson and, in particular, of its mathematics program. According to them, the school enables them to succeed because of:

- its small classes
- the accessibility of teachers outside of class. (one student: "This is the way we get known by them -- they find out what we know, what we don't know.")
- the opportunities for extra projects beyond the tests and classwork, with the extra credit and attention which these entail
- the fact that the teachers "notice what we say"
- the fact that the teachers "want to teach"

The two students taking university mathematics courses added one factor (in separate interviews) -- the consistent stress of the teachers on students' understanding the concepts involved and their parallel undervaluing of memorization of mathematical facts. Said one, "We learned how to reconstruct formulas if we forgot them, and I can still do that. I don't like it that, in the university courses, all that seems to matter is whether you can remember the material on the tests." Later, he identified another feature of the Jackson program that was significant for him: "In the courses at Jackson, there is a lot of tying of mathematics to the real world and a lot of tying together of mathematical concepts -- like in geometry, where we saw some of the same concepts approached both through plane geometry and through vectors. Even the tests challenged us to make these connections."

This emphasis on understanding mathematics, as opposed to merely being able to use it, is one of the distinctive features of the program. It is a pedagogical principle often preached in this country, but it is hard to imagine a more thorough or consistent attempt to put it into practice than that observed at Jackson. It is the bedrock of the curriculum put together by Bill Brooks, the head and guiding spirit of Jackson's mathematics program. As the students quoted above implied, Brooks and the other teachers place minimal value on students' being able to regurgitate memorized material and they avoid an algorithmic approach to teaching mathematics; instead, they place a premium on students' taking the time to reconstruct formulas and other constructs on the basis of understanding. In the words of Brooks, "We work for a deeper understanding of key concepts, and for more comprehension of the heuristic planning that ought to guide many decisions during the process of analyzing a problem."

The central role given to understanding implies another distinctive feature of this program -- use of time. Again, the words of Brooks: "We have based our notion of use of time on the belief that ordinary curricula squander time on easy topics. We try not to. Instead, at any point a class will take time to review a topic, or to look at it more deeply, or to look at it in more minute detail, if that seems appropriate." As an example, he mentioned that logarithms are typically approached in four different ways in order to heighten understanding. He tells the other teachers to rely on their instincts and to "use your time where you need it."

Though the philosophy of teaching for understanding and of using time as an ally in this process extend throughout the curriculum, it finds its richest manifestation in calculus. The syllabus for calculus has been carefully developed over more than a decade to take advantage of the fact that many Jackson students take calculus beginning in their junior year (making time a luxury for the teachers) and of observations made over that period of time of strengths and weaknesses evinced by the students in the calculus courses. It is an innovative course, mainly developed by Brooks, which begins, not with the notion of differentiation but with integration -- in particular, as it represents the work done in compressing a spring. From the posing of that initial work problem, students are led into a view and appreciation of calculus that few other students in this country get. It is a challenging regimen, as evidenced by Brooks' statement about the homework policy espoused in the course: "We use small, bite-sized tasks only occasionally -- to avoid allowing students to succeed in doing homework without thinking about it." Instead, students are assigned problems which require time and thought to solve, and which often connect the mathematics to the real world in imaginative and memorable ways. During our interview, the program graduate now in the university was able to recall one such problem, word for word, even though it had been four years since it had been assigned.

Jackson's teachers have found that not all of their students display exceptional proficiency in mathematics. Therefore, they try to maintain a two-track program. Again, the words of Brooks: "Past experience has demonstrated that those students who are mathematically gifted usually reveal themselves early in the seventh grade. This is not a matter of opinion, but of fact. Consequently, we try to begin the two-track program before the end of the seventh grade.

"For the faster track, the curriculum consists of algebra in grade seven; more advanced algebra, including trigonometry, in grade nine; geometry in grade ten; and calculus in grades eleven and twelve. A few students sometimes take one or more math-related courses in addition to this, such as the course in finite mathematics, university courses in computer science, or university courses in mathematics, physics, or chemistry.

"For the alternative track, the seventh-grade program is also algebra, but -- from the time when a separation is made -- the pace of the course is somewhat slower. The ninth-grade course is again similar, but with a slower pace. Grade ten is devoted to geometry. Grade eleven is a precalculus course that reviews and extends the work in algebra, geometry, and trigonometry. In grade twelve, students may begin calculus (if they appear to be ready), or may take finite mathematics."

Obviously the design of the two-track system has drawn careful and imaginative thinking. Does it work? Unfortunately, not very well, and therein lies one of the more harmful repercussions of the school's rocky period of transition. The two-tracked system has been thwarted by scheduling conflicts in the past few years ("the tail that wags the dog," complains Brooks), fed in part by the school's ambitious foreign language program, which have forced the department to group the students rather heterogeneously. The process of redirecting the school has only served to cloud the tracking system even further. The teachers lavish individual attention on the students outside of class, but still the disparity between those who are catching on quickly and those who are not has been evident to Brooks and the other teachers, and yet they have not seen any easy way to enforce the two-track system.

In general, the curriculum with calculus as its centerpiece, is innovative, ambitious, and, to my mind, inspiring. Primarily, its development is the work of one man, Brooks, though the other teachers all seemed comfortable working with it. The support of the new administration for the mathematics curriculum, insofar as it is there at all, has been muted, and the possibility that changes would be requested (the feasibility of changes in the approach to algebra and the inclusion of a separate course in analytic geometry were discussed in committee meetings) cast a dark cloud over the program at the time of my visit in November 1983.

Jackson's mathematics program was weathering the school's period of transition, but the turbulence was having a greater effect than it might if the leadership were more focused and forceful. Decisions about the program can emanate from at least five sources. The school's new half-time director controls the academic life of the school; its principal handles scheduling; a university faculty committee assumed the task of making curriculum recommendations; for the past decade, Brooks has sustained the development of the program with its distinctive emphases on understanding and coaching; and, finally, many of the managerial responsibilities, such as teacher supervision, were delegated by Brooks to a five-year veteran of the program, Paul McGregor.

In this leadership melange, differences of opinion about the mathematics program have begun to show up. The new director apparently leans toward a more defined, more challenging, and more frequently used testing program. (I was not able to interview him.) Brooks and McGregor, on the other hand, are chary about being drawn toward a program "whose value is defined by the difficulty of its tests." The director and faculty committee -- distressed at the near breakdown of the two-track system -- have indicated a desire for a separate analytic geometry course in the curriculum which could soften the transition to calculus for the less talented students. For his part, Brooks questioned the wisdom in the suggestion, maintaining that no one was yet sure of the nature of the difficulties being experienced by these students, and that the failure of the two-track system has been due in large measure to the school's scheduling problems.

Both Brooks and McGregor were uncomfortable with the task of teacher supervision -- by their own admission -- with McGregor reluctantly assuming the responsibility. The faculty committee promised to help out with class observations, but that promise had not been fulfilled at the time of my visit. And, as far as the training of new teachers goes, money available for summer training had dried up, and there were no signs of any efforts to raise more.

Thus, the mathematics program at Jackson appears to have been made more vulnerable by a rather disjointed leadership structure. If the communication within that structure improves, then the differences of opinion can lead to a healthy annealing of the program within the larger framework of the school. If it doesn't improve, then the program will continue on its fragile course.

There is an irony in this situation that warrants mention. In the sense of visionary leadership -- having an ideal and inducing colleagues to share it and work toward it -- Brooks's leadership is outstahding. Indeed, it is his adherence to his vision that renders him unbending in the face of outside criticism or the suspicion that he will be asked to make substantial changes. His vision is a mathematics curriculum based entirely on student understanding -- both of mathematical content and of problem-solving heuristics. Just as several writing educators (e.g., Nancie Atwell and Tom Newkirk) advocate the creation of "the literate environment," a place where people read, write, and talk about reading and writing, so does Brooks seem to envision a mathematical environment where people think and talk about mathematics, and look for its presence in unanticipated settings.

At the time of my site visit, there were four teachers in the program: Brooks, who had been there for eleven years; Paul McGregor, who had been there for five years; a three-year member of the department, who was preparing to move back to England; and a teacher who was in his first year in the program. Replacing teachers at Jackson is no simple task. Not only does the demanding curriculum call for bright and committed people to teach it, but the teachers are underpaid, earning about two-thirds of what beginners get in the local public schools. Furthermore, the salary structure, as inherited from the days of being tied to the university, offers no system of seniority -- all master's degree teachers make the same salary, no matter how long they have been at the school.

Furthermore, money that used to support summer training for new teachers was no longer available, and the first-year teacher was left to adapt through detailed course syllabi, occasional class visits from McGregor, and the opportunity to observe other teachers teaching. During my visit, he was quite open about his lack of confidence in teaching a beginning calculus section, but equally clear about the growth of his process skills: "I'm learning that what you need to do to motivate these kids is to keep asking questions like, 'Okay, now what do you think about this?' Get them active and they start learning." The office configuration of the teachers seemed to add to his chances to pick up, however casually, the teaching skills necessary to succeed with this challenging curriculum and with these challenging students. They were all located together on the first floor of a house that abuts the school, with no doors separating one teacher from another.

It is in that office space, as the students noted, that much of the individual attention is gained. McGregor, especially, seemed generous with his office time, letting students linger, singly or in groups, even when the topic of conversation had drifted far from mathematics. However, both he and Brooks are not completely comfortable with the looseness and lack of control over the office interactions. As Brooks put it, "Even when the topic of conversation in these office visits is mathematics, it seems wasteful to go over the same things again and again. It's hard to tell whether the need being expressed is cognitive or emotional. If it's emotional, then concentrating on the content would seem to do little good."

Recognizing and responding appropriately to the emotional needs of these gifted and talented students constitutes what seems to be a weak feature of this program (and perhaps the school). The affective is not ignored or undervalued -- that is not the problem. It seemed more a matter of what to do about the affective needs. Brooks has taken pains to make coaching a distinctive feature of the program's teaching. An example from his calculus class: "Those of you who are still having trouble with this -- about half of you -- find someone in the class to work with you on it for the next ten minutes." More generally, the pervasive strategy of expecting students to rederive formulas and to reconstruct their understanding of concepts has an essential component of coaching to it. (The implied message is: "You don't need to memorize that. You can figure it out.")

But even the coaching is primarily tied to cognitive goals. When it comes to responding to the students' emotional needs that are peripheral to their cognitive needs, however, the staff seemed to lack conviction or a sense of direction. Admittedly, this is an area in which mathematics teachers have little training or expertise, but the emotional and behavioral needs of gifted youngsters are often closely aligned with their cognitive needs and, just as often, they call for adult intervention. For example, sarcastic comments from students were rampant in several observed mathematics classes at Jackson, some of them seemingly harmless, others potentially hurtful to the students on the receiving end. In some of these observed interactions, the behavior was doubly disturbing because they concerned comparisons of test grades. Neither teachers nor students allowed the interactions to distract much from the business of learning mathematics, but the behavior seemed antisocial enough to warrant adult intervention. Oddly, this phenomenon appeared in observations of upper level courses; the British teacher I observed in the seventh-grade class showed a typically British intolerance of such antisocial behavior in the classroom; indeed, she kept all destructive behavior to a minimum.

In the end, however, the words of the students stand as proof of their devotion to the teachers and to the teachers' deep concern for their welfare. They sensed that these four people "want to teach" and that they "notice what we say." They also were grateful for the respect for them expressed in the high expectations of them as learners of mathematics through understanding, with test performance a secondary, albeit important, touchstone of success.

* * *

SUMMIT SCHOOL

The Summit School is a statewide school for students in grades 11 and 12 who are talented in science and mathematics. The mathematics curriculum ranges from second-year algebra to second-year calculus, and students are carefully placed in appropriate courses. The administration provides a comprehensive support structure for students in this boarding school. Collegiality and sharing among mathematics staff are exceptionally high and very influential in the success of the program -- e.g., teachers regularly observe and consult each other. The department head carefully nurtures a "teacher-as-learner" atmosphere in the program. His leadership and support of the teachers, along with his visionary approach to innovative curricula, adds much to the vibrancy of the program. He is also a close and trusted link with the supportive school administration.

The Summit School is the North Carolina School of Science and Mathematics.

THE SUMMIT SCHOOL

> "There are ten or fifteen students in this school who ask the questions a teacher lives for."
>
> Mathematics department head, The Summit School

> "The pace of work here is intense, but the students make it worthwhile. The other day a student came in to my office, we talked for an hour or so, and I felt recharged for another two months."
>
> Mathematics teacher, The Summit School

> "The key to the success of the mathematics program is the dedication and total commitment of the teachers, and their striving to meet the needs of the kids. It is an environment where the teachers are given the freedom to be creative and innovative, but also the freedom to burn themselves out."
>
> Dean, The Summit School

The buildings that house The Summit School used to house a state hospital. Acres of space and stately oaks still suggest the restfulness of a hospital but, in doing so, they belie the environment within. Whatever peace and tranquility used to reign in the hospital's rooms and hallways are gone, replaced by an intellectual energy that seems both pervasive and constant. Teachers and students thrive on the energy and on their contact with each other; and because Summit is a boarding school with teachers who log long workdays, that contact is extensive.

In design The Summit School was, until recently, unlike any other school in the country. Its students are drawn from across the state to spend their eleventh and twelfth grades at Summit. They are talented in mathematics and science, and they are carefully screened for their willingness and ability to work as hard as this school demands.

Because of the special nature of the school, one of our challenges was to uncover anything about the excellence in Summit's mathematics program that might export to other schools. Since the school had been in existence only for four years when we visited in December of 1983, the mathematics staff was unwilling to say that any of their practices or strategies are exportable. Their caution derives from Summit's young age, but there is also the fear that an ivory tower may be closing around them, that they are too isolated from regular public and private schools. We, however, saw some things -- curriculum decisions, teaching strategies, communication patterns -- that we believe can be used by other schools.

The Summit School has received more national attention than perhaps any other secondary school in American history, with articles in such publications as The Christian Science Monitor and The Wall Street Journal. The school is so young and experimental that its teachers and administrators run the danger of wilting in the spotlight or of tripping over the footlights. The ivory-tower fear is worth tracking in the coming years, as is the trend we noted among the school's administrators to be more outward-looking -- for funding and consultation -- than inward-looking to the needs of their teachers and students.

No matter what course Summit's story might take in future years, for the time being the school pulsates with an intellectual energy that can drown out any fears or criticism. It is also an energy that envelops anyone drawn near it -- witness our experience as site visitors. There were two of us who visited Summit for the study, and when we let it be known on our first day that we would like to interview a few students, fifteen of them appeared at 5 o'clock and kept us riveted to our chairs and notebooks until 7 o'clock. Like the teacher quoted above, we left the school recharged, and feeling that we were witnessing something very special in American mathematical education.

The Summit School began in 1980, with the special support and funding by the state governor's office, as a statewide school for eleventh and twelfth graders deemed talented in mathematics and science. The approximately 400 students -- carefully chosen to represent a cross-sampling of the state's population -- live at the school and are completely subsidized for tuition, room, and board. The program's cost has not been cheap: state coffers provide 3.5 million dollars a year. (Ninety percent of the operating budget is state-financed.) To offset the cost to the state, the school's development office has raised more than 7 million dollars from private sources by the time of our visit, many of them companies represented in the technologically fertile area where the school is located. Federal support has been minimal, despite the original intentions of the school's designers that the federal government share equally with the state and private sources in the running of the school.

Because of its cost and because of the considerable public criticism of the school as elitist, The Summit School has a mandate built into its design to spread the wealth, so to speak, through a series of outreach programs. Summer workshops, equipment loans, and consultation have all been made available to districts throughout the state, and the school has served as a test site for the state's new competency examination. In addition, the Babcock Foundation was providing funding which each year enabled several teachers of science and mathematics from high schools throughout the state to spend the year teaching at The Summit School.

Administratively, the school seems a blend of the secondary and postsecondary. The hierarchy includes a director, a dean, and a principal, with the last appearing (according to several teachers) to have the strongest day-to-day ties with the school's academic pursuits. There is also a Board of Trustees, a blue-ribbon panel of national experts in mathematics, science, and education. By all accounts, their recommendations have been heeded carefully in setting the tone of the school programs.

The school's leaders recognize that, as it evolves, that tone must be defined by more than curriculum and test scores. It is not enough to offer talented students more challenging courses and a chance to work together. The director of development, who has spearheaded the drive to acquire the 7 million dollars of support, gave his definition of the spirit that drives the school: "We have a strong sense that we are, and should be, preparing our students for leadership. We communicate that to the businesses and foundations we talk with. We make it clear to them that it is in their self-interest to contribute. Self-interest, not charity, should be their motivation for contributing."

At the administrative level, therefore, there appeared to be a working sense of mission. The teachers, however, were not so sure that it has filtered through the whole school. At least that was the assessment of one of the mathematics teachers, who lamented that the administrators felt obliged to focus so much of their energy and attention outside of the school. "I hear very little from the administration about what goes on in the school. It's been hard in the past year to get them to define a sense of mission for us. Academically, it's the teachers who pretty much run this school."

Under the leadership of their department head, the mathematics teachers have been honing their own sense of mission, distinguished by a strong and unified sense of what kind of mathematics ought to be offered to Summit students and how it ought to be taught, and by a strong commitment to equal access to the learning of mathematics. In describing other exemplary mathematics programs, in settings more traditional than Summit's, we have noted similar senses of mission among the staffs -- e.g., to attain excellence with equity, to keep all students in mathematics courses for four years of high school, to develop a sense of self-responsibility in all students, or to develop in students a sense of what "good" mathematics is. The visions and sense of mission that have unified these staffs and given their programs energy and life have varied from school to school, but their influence in so many programs marks them as a significant factor. The developing sense of mission in the Summit program was only one echo of other exemplary programs. There are others, as described in later sections.

The students at The Summit School are clearly exceptional, but teachers and administrators were careful to inform us that they are not necessarily the top students in the state. According to the dean, "Less than 50 percent of the student body could be described as gifted." This is a result of the multiple criteria used to select students, which aim for a balance by race, sex, and geographic distribution through the entire state. To bring together these young people is an ambitious undertaking, especially since the state's profile extends from several large cities to a broad expanse of rural communities, a mixture made even more complex by the Southern history of racial polarization. Consequently, there is an elaborate selection process that combines nominations, interviews, testing, and then more interviews. Generally there are around 800 applicants for 200 places in an incoming class, and the resulting student population runs the gamut from the confident and gifted to students who, despite their previous records and proven potential for further success in science and mathematics, are conservative, cautious, and sometimes intimidated. As several teachers described it, the general tenor of the student body is generally conservative. Said one teacher: "They are conservative enough so that we don't always find it easy to incorporate innovations. For example, they put up a fuss when we tried to replace a course in differential equations with one in finite mathematics. They complained to us that they knew differential equations is an established course in colleges and that they didn't want to be left out." One of the many praiseworthy qualities of the teachers is the quiet respect they have developed for this student caution. Rather than fight it, they flow with it and nudge the students when the situation warrants it. for example, they finally succeeded, with some diplomatic persuasion, in instituting the course in finite mathematics in place of differential equations.

We witnessed some of the students' ingrained caution and conservatism in several classes. For example, in one precalculus class, only one student asked a question that was not aimed at clarification, and even his questioning seemed tainted, apparently driven by a desire to show how much he knew. This was an extreme manifestation, but not an aberration for the students' caution also was evident in several of the first-year courses we observed. In contrast, in an early-morning, third-semester calculus course, caution and conservatism were thrown to the wind. Almost all the students kept up a lively banter of exploratory questions and shared observations, both with the teacher and with each other. This lack of uniformity in student style, which was surprising to us, had obviously challenged the school's planners and teachers.

Because of the wide variety of student backgrounds and attitudes, the planners cut no corners in preparing to meet their students' emotional needs. All educators who work with gifted students recognize that giftedness often has a price, and the price for many gifted young people is emotional stress. Here, at Summit, is a school which brings together young people from vastly different social backgrounds -- some gifted, others not, but all with the potential for significant success -- and puts them in a very challenging and, at least to some, an intimidating environment. In light of the evident risks, it would seem essential to give these students as much support in adapting to the environment as possible.

And here was one of the most impressive aspects of this educational experiment. The Summit School has left little to chance in making it safe for its students to take on the risks of immersing themselves in the school. There is an evening study skills course which is required for all new students, a solid tutorial program -- at least in mathematics, our only observed department -- and a counseling program which conducts support groups for the students. (More importantly, perhaps, the counseling director seemed highly sensitive to the potential risks and danger points for the students, and spoke of the several strategies her staff has employed to help students to survive.) To mitigate intense and possibly unhealthy competition among the students, the school has decided against having an honors program and against computing class rank. Furthermore, to apply a little weight to the support programs, the school has established a mandatory two-hour quiet study time for all students, an edict that at least a couple of the mathematics teachers thought was too protective and authoritarian. The general attitude of the administration, however, is that they would rather err in the direction of being too protective and not risk negligence.

The mathematics department's attention to student placement complements nicely the school's support programs. Precalculus is a required course and other courses have been carefully tailored to make sure that all students are well prepared to take it. In principle, all entering students have taken algebra II in their previous schools. But, as one of the teachers wryly observed, "Some have taken algebra II, but not so you'd notice they have."

When the school first started, the mathematics department used student SAT scores as a placement device but found them to be inadequate for singling out the students with weak algebra II backgrounds. They therefore developed their own placement test and are now confident that they can place students correctly. For the students with the weakest backgrounds, there is a course that covers algebra II and a little bit of extended work in a year; for those with stronger backgrounds, there are courses that move through algebra II and trigonometry, and through algebra II and precalculus in a year. The remaining students, of course, begin with precalculus or even higher courses. (In the third-semester calculus course which we observed, there were a couple of first-year students.) The staff stays carefully tuned to how well students are placed and, by their own testimony, "We allow a fairly fluid movement up and down among courses." In fact, the dean of the school praised the mathematics staff's ability and willingness to create new courses, halfway through the year, when they seemed warranted to meet student needs. Courses meet three times a week and the typical teacher load is seven courses. Thus the flexibility that allows students to move fluidly to suitable courses does not come without cost to the teachers.

Precalculus is the acknowledged "center of the curriculum," and the staff's careful thinking about the course has determined their thinking about the rest of the mathematics courses, as well. The precalculus syllabus contains six pages of topics alone, and the staff is united in their notions about approaching those topics. As the department head described it: "We avoid stressing facts, memorization, and the traditional theorem-proof approach. Instead, we aim for a discovery, think-it-through approach." There is much that unites Summit's mathematics teachers, but their unity on this pedagogical approach is especially rock-solid.

The attention to how students learn in their mathematics courses extends beyond precalculus and, in fact, has influenced staff decisions about what students learn. The prime example is in programming where, under the persuasive influence of the department head, Paul Thompson, courses in BASIC have been replaced by courses in LOGO. The teachers seemed unanimous in their opinion that, with its emphasis on programming structures called procedures, LOGO is superior in inducing students to think about "What do I need to know?" in order to solve a particular problem. As if to underscore the wisdom of their decision, a student reported to one of the teachers during our visit, "I'm doing much better in math now that I treat problems as if they were LOGO programs and break them up into pieces."

The student who reported this bit of personal growth is female, as is the teacher in whom she confided -- circumstances that are not at all coincidental. The three fulltime women mathematics teachers have worked to sharpen the lines of communication with female students. Their focused determination resulted from interviews with several girls a few years before our visit, interviews that revealed how intimidated they felt in class with so many talented boys. No matter how talented they themselves were, they often perceived the boys as aggressive. The resulting patterns would be familiar to teachers in other mathematics programs: boys dominated discussions in the classroom and dominated the use of computers outside of the classroom.

The women teachers convened an after-school session for female students, allowed some airing of feelings, and suggested they meet on a regular basis. They have continued to meet and the group has evolved into a popular club where, according to one of the three women teachers, "We raise their consciousness about the importance of asking questions in class. We discuss and practice some of the tricks the boys have learned in order to succeed, and we have established some problem-solving groups. Several boys have begun to show up for the meetings, and the girls decided to let them take part." One effect of the club, as the student report about LOGO hinted, has been a balancing of computer use among male and female students.

Computer use appeared at an especially high pitch at Summit. Up and down the hallway of the mathematics department, computers were located wherever they would fit -- a few in this room, a single one in that office -- and wherever they were, they were regularly used. Primarily, they were regularly used for programming. Besides LOGO, we saw signs of "C" and PASCAL. There seemed, however, to be little use of computer software in the mathematics classes. The one noted exception was the use in several courses of graphing software, such as that produced by Conduit.

In good part, the absence of much software from Summit's curriculum derives from the healthy skepticism of Thompson, the department head, which is grounded in his high regard for his teachers. As he told us, "Until I see software that does as good a job in the classroom with students as most of the teachers in this department, I'll continue to be skeptical about its usefulness."

Thompson is a man with strong opinions about teaching mathematics who has all the energy and forcefulness needed to act on those opinions. He is, in fact, a fireball of energy who believes strongly in a style of teaching that challenges students to think, observe, and appreciate good mathematics; who believes equally strongly in a program structure based on "teacher as learner," where teachers take it upon themselves always to be learning new things; and who believes in a program supported by a deep commitment to collegiality among the teachers. Thompson supports his strong opinions by being the primary model for all of them, demanding of himself at least as much as he demands of his teachers. ("It's been a long time since I got out of here before 7:00 in the evening.")

He also has been the primary force in all the curricular innovations and has infected the rest of the staff with his enthusiasm and vision. In the formative period when the school was being planned, Thompson was hired to develop the mathematics and computer science programs, and he has made each hiring since then a careful, deliberate, and resolute choice. The resulting staff is a blend of different personalities and backgrounds, different enough to make us curious and lead us to ask several teachers how he managed to get the department he both wanted and needed from such a diverse group. "Magic," said one, who continued, "His instincts are so good, he seems to be able to sniff out applicants' resumes." And he has persisted, said this teacher -- "often in the face of some real heel-dragging from the administration, who are technically supposed to approve the hirings. He's been able to get the people he wants, though."

As we distilled from all our study data the profiles of the exemplary mathematics leaders we met, we noted that they usually combined some of the following: they were able to get things accomplished for their programs, despite administrative hurdles; they championed their teachers whenever they could; they fostered a sense of professionalism among their teachers; they infected all of their colleagues with their visions of even better programs; and they served as the primary models for all they preached. Thompson epitomizes all of these qualities.

All of the circumstances at The Summit School seemed ripe for excellence. The money is there; the talented and motivated students are there; and in the glare of intense publicity, the high expectations also are there. But, as we have noted for other exemplary programs -- old or new, rich or poor -- the excellent results would just not exist if it were not for the qualities, attitudes, and practices the teachers bring to the programs. In his adamance about getting the teachers he wants, Paul Thompson has recognized this. Fortunately, in their willingness to accede to his wishes, however slowly, so have the school's administrators.

One of the strengths of the Summit mathematics teachers has already been mentioned: they do whatever it takes to assure success for their students -- their own placement tests, multiple entry courses for students with different backgrounds, their special attention to guarantee females equal access. They are also extraordinarily generous in their availability to students: one student remarked to us that he could always find a teacher to help him any time between 8:00 in the morning and 10:00 in the evening. Like their counterparts in other exemplary programs we visited, the eight teachers refuse to tolerate any possibility of failure for their students.

They have other powerful attributes, as well. Most noticeable to us was their careful attention to teaching style, to how they deliver the mathematics to their students. Thompson, for instance, is charged and flamboyant, committed in his instruction to what he calls "big picture instruction." In a LOGO class, he led a spontaneous discussion of "What makes something mathematical?", a discussion spurred by a binary search problem which, in its passing to the mathematics involved, touched on Mozart's piano concertos and on Finnegan's Wake. In a precalculus class, he used a style resembling that of a law professor. ("That logic is sound, but you didn't explain it very well.") He has been known on several occasions to grab a second-year student from the hallway to recollect in front of a class of first-year students about a concept or problem which was particularly nettlesome.

The other teachers do not try to emulate Thompson's flamboyance -- it is too much of a personal stamp -- but they do try to learn from him. Said one man relatively new to teaching, "I've learned from Paul the value of putting silent pressure on students who don't prepare, letting them squirm a bit while I confront them with questions." From watching this teacher in class, it was evident that he also was picking up Thompson's use of challenging questions and his insistence that students take care in formulating their answers to mathematical questions. The following are quotes from his precalculus class:

- "Very good! That's shorter than the explanation I would have given."
- "How many of you think you can take log base two of both sides of an inequality and preserve the inequality? Why or why not?"
- "I think I understand your question, but others do not. Try and rephrase it."

The emphasis on student responsibility and self-discipline reflected in these comments and questions was one shared by all the teachers, one of whom told us: "We try to impress on the students that they ought to look to themselves first, before they go to blaming teacher, book, or school."

The use of questions intended to make students think a bit before they answer is a hallmark of most of the teachers and classes in the department, though the notable exception was unfortunately the lowest level of algebra II -- in this school's hierarchy of courses, the virtual equivalent of other schools' general mathematics courses. There the concern of the teacher seemed to be the quantity of material covered, and the concern of the students seemed to be what was going to be on the upcoming test.

This exception aside, there was uniformity in much that these teachers did during our class visits, and that results from an extraordinary sense of collegiality which they have developed in the short time that they have been together. Said one, "We usually look at each other's tests and worksheet questions." Another pointed to the indirect benefits that accrue to students from staff collegiality: "A student told me that he had heard the same suggestion concerning the organization of work from three different mathematics teachers. That happened to be something we had discussed together." When possible (and it usually isn't, given the heavy teaching schedules), the teachers sit in on each other's classes, a practice which can serve to spread the wealth. In the classes of two different teachers, we saw the innovative use of homework discussions to foreshadow and act as advanced organizers for the content of the next day's classes. One teacher had observed the other several times in the preceding months, and we could only infer that the practice had been consciously imitated.

Though they do meet formally as a department for two hours a week, most of the teacher interactions occur in hallway encounters and office visits. They love it and crave even more. "We hardly ever get to talk about pedagogy," said one, "and I would like to have others sit in on more of my classes." To one of the visiting Babcock Fellows, teaching at the school for one year, the experience of being part of this staff was a revelation: "The staff interaction here is so rewarding! I never thought that teachers communicating with each other was so important. When you think about it, however -- and I don't mean to be flip -- teachers in regular schools end up spending 90 percent of their time with people who haven't graduated from high school yet, and they hardly get a chance to learn from each other."

Without doubt, therefore, the primary source of the energy that courses through the mathematics corridor and classrooms at Summit is not the curriculum, nor is it the select student body. It is the cohesive and extremely dedicated group of teachers, who more than live up to Thompson's vision of teacher-as-learner. This is not to ignore the rough spots that do exist. The sad lack of engaging questions in at least a couple of the lowest level classes was mentioned earlier. Though Thompson's classroom challenges to his students are carefully calculated, we wondered how many of the students on the cautious end of the attitude spectrum (and there are many at the school, as mentioned before) were internally pulling away from his law professor tactics. And we saw only a few classes in which students did any work at the board, a circumstance we thought odd, given the interest of the teachers in developing opportunities for discussion.

These potential rough spots deserve attention, but to dwell on them would distort the superb professional community and mathematics program put together by Paul Thompson and his teachers. Indeed, perhaps the real rough spot facing the Summit mathematics staff in these formative years will be their capacity to sustain the level of energy necessary for the program to continue to thrive. In addition to their considerable devotion of time to their mathematics classes and students, all of the teachers are heavily involved in coaching, clubs, committees, and the Summer Outreach Program, which fulfills the school's obligations to schools in the rest of the state. Burnout for these teachers is a possibility they face all year long. So far, they have faced it with enthusiasm, grace, and success.

* * *

HYPOTHESES

Field research for the Study of Exemplary Mathematics Programs developed the following hypotheses for factors associated with excellence in precollege mathematics:

1. The community values mathematics achievement and these values are effectively communicated to students -- the students want to learn.

2. Homework plays an important role -- in amount and frequency, in the feedback given, and in its connection to classroom practice.

3. The whole program is structured, and understood by staff and students, so that students can and do move flexibly within an array of courses and levels to maximize success.

4. The curriculum has the blessings of the mathematics staff. If they have not had a hand in developing the curriculum, they have at least adapted to it and developed a sense of ownership of it.

5. High expectations for success in mathematics are consistently and effectively communicated to students.

6. There is a consistently supportive environment for learning in the classroom that accommodates risk-taking.

7. Class time is used efficiently by both teachers and students.

8. Mathematics teachers spend considerable extra time working with students and/or preparing materials.

9. Staff are dedicated and function as a cohesive, sharing, and mutually supportive unit.

10. Exemplary programs are characterized by the kind of leadership that results in a well-run, well-organized department that frees teachers from non-instructional distractions.

11. Exemplary programs are characterized by leadership that makes it possible for teachers to feel and act as professionals, and that stimulates questionning, sharing, and taking part in ongoing professional interactions.

Further research has indicated that the factors seem to vary in importance, but researchers for the study believe all are worthy of some attention. Therefore, we have developed the following annotated bibliography of articles, documents, and books that touch on one of more of the hypotheses. These are suggested readings, and in no way constitute a comprehensive list. They are grouped under four categories: General, Curriculum and Its Implementation, Leadership, Teachers and Teaching.

ANNOTATED BIBLIOGRAPHY

I General

Alexander, William M. and Paul S. George. The Exemplary Middle School. New York: Holt, Rinehart and Winston, 1981.

> A basic textbook for students in the field of middle school education. It defines the middle school concept, describes in detail the characteristics of exemplary middle schools and illustrates the implementation of these characteristics in practice.

Hurd, Paul DeHart. "State of Precollege Education in Mathematics and Science." Paper presented at National Convocation on Precollege Education in Mathematics and Science, May 12-13, 1982. Washington, DC: National Academy of Sciences and National Academy of Engineering.

> This report identifies trends and issues facing precollege education in mathematics and science. By synthesizing a variety of reports and surveys, it provides a clearer statistical profile of such converging trends as achievement declines, the growing shortage of qualified teachers, and so on.

Driscoll, Mark J. Research Within Reach: Elementary School Mathematics. Reston, VA: National Council of Teachers of Mathematics, 1981.

Driscoll, Mark J. Research Within Reach: Secondary School Mathematics. Reston, VA: National Council of Teachers of Mathematics, 1982.

> These two books, based on interviews of national samples of teachers, identify topics of special interest to teachers and interpret the research literature for each topic in a separate chapter. Each chapter contains suggestions for classroom practice.

Penick, John E. and Richard Meinhard-Pellens, editors. Focus on Excellence. Vol. 1, numbers 1-5. Washington, DC: National Science Teachers Association.

> These five monographs have been drawn from the 1982 Search for Excellence in Science Education of the National Science Teachers Association. They describe exemplary programs and practices in the following areas: Science as Inquiry, Elementary Science, Biology, Physical Science, and Science/Technology/Society.

Carpenter, Thomas P., et al. Results from the Second Mathematics Assessment of National Assessment of Educational Progress. Reston, VA: National Council of Teachers of Mathematics, 1981.

> This book summarizes the results of the Second Mathematics Assessment -- a profile of what American students know and don't know in mathematics at ages 9, 13, and 17.

Hart, K.M., editor. Children's Understanding of Mathematics: 11-16. London, England: John Murray Ltd., 1981.

> From a British enterprise similar to the American National Assessment, this report describes in detail what British children know and don't know about mathematics. The study included interviews and some attempts at remediation. Hence, suggestions for instruction abound.

II *Curriculum and Its Implementation*

Clement, John, Jack Lochhead, and George S. Monk. "Translation Difficulties in Learning Mathematics." *The American Mathematical Monthly*. vol. 88, No. 4, April 1981, pp. 286-289.

Herscovics, Nicolas and Carolyn Kieran. "Constructing Meaning for the Concept of Equation." *The Mathematics Teacher*. Vol. 73, No. 8, pp. 572-581. November 1980.

Rosnick, Peter. "Some Misconceptions About the Concept of Variable." *The Mathematics Teacher*. Vol. 74, No. 6, September 1981, pp. 418-420.

> These three articles discuss various aspects of students' difficulty in learning algebra. Each, especially the article by Herscovics and Kieran, offers suggestions for instruction.

Confrey, Jere and Perry Lanier. "Students' Mathematical Abilities: A Focus for the Improvement of Teaching General Mathematics." *School Science and Mathematics*. Vol. LXXX, No. 7, November 1980, pp. 549-556.

> Some results from a study of general mathematics curricula, citing some of the mathematical abilities where general mathematics students compare unfavorably with many of their peers who are in higher tracks.

Erlwanger, Stanley H. "Case Studies of Children's Conceptions of Mathematics - Part 1." *Journal of Children's Mathematical Behavior*. Vol. 1, No. 3, Summer 1975.

> Interviews with several elementary school students that revealed some basic misconceptions about mathematics.

Hansen, Viggo P., editor. *Computers in Mathematics Education: 1984 Yearbook*. Reston, VA: National Council of Teachers of Mathematics, 1984.

> This yearbook gives a comprehensive look at the impact of the computer on the mathematics curriculum.

Hilton, Peter. "Current Trends in Mathematics and Future Trends in Mathematics Education." *For the Learning of Mathematics*. Vol 4, No. 1, February 1984, pp. 2-8.

> A proposal for changes in elementary and secondary mathematics curricula and instruction in light of trends in mathematics.

Hoffer, Alan. "Geometry is More than Proof." *The Mathematics Teacher*. Vol. 74, No. 1, January 1981, pp. 11-18.

> The article describes, with examples, the five levels of development in geometrical thinking as represented in the van Hiele model. It also discusses the kinds of instructional activities that correspond to each level.

Usiskin, Zalman. "What Should Not be in the Algebra and Geometry Curricula of Average College-Bound Students?" The Mathematics Teacher. Vol. 73, No. 6, September 1980, pp. 413-426.

The article's title is self-explanatory. A set of fervid and somewhat controversial recommendations about eliminating topics from the algebra and geometry curricula.

III Leadership

Ad Hoc Committee on Applied Mathematics Training. The Role of Applications in the Undergraduate Mathematics Curriculum.
Washington, DC: National Academy of Science, 1979.

Conference Board of the Mathematical Sciences. New Goals for Mathematical Science Education. Washington, DC: Conference Board of the Mathematical Sciences, 1984.

Two committee reports that raise issues and recommendations demanding the attention of leaders in mathematics education.

Hall, Gene E., et al. "Change in High Schools: Rolling Stones or Asleep at the Wheel?" Educational Leadership. March 1984, pp. 58-62.

A report of a study that showed, among other things, how limited the high school department head is as an agent of change.

Stanford Engineering and Management Systems Company, Inc. Visionary Leaders (Interim Report). Arlington, VA: Stanford Engineering and Management Systems, Inc., July 1983.

A report of a study of business leaders revealing distinctions between leader as manager and leader as visionary. It offers food for thought for educational leaders, in particular, leaders in mathematics education.

IV *Teachers and Teaching*

Floyd, Ann, editor. *Developing Mathematical Thinking*. London: Addison-Wesley, 1981.

> A collection of articles on the theme of how children learn to investigate and solve mathematical problems. It contains case studies, articles on the psychology of learning, etc., with suggestions for classroom activities. It is especially targeted to the nonspecialist teachers of mathematics of children between the ages of 5 and 14.

Good, Thomas L., Douglas A. Grouws, and Howard Ebmeier. *Active Mathematics Teaching*. New York: Longman, Inc. 1983.

> A description of the Missouri Mathematics Effectiveness Project, a study of intermediate and junior high school classrooms, with a discussion of implications for classroom teaching. The project has identified an effective program for mathematics instruction -- a combination of problem solving, review, practice, and new material.

Lochhead, Jack and John Clement, editors. *Cognitive Process Instruction: Research on Teaching Thinking Skills*. Philadelphia, PA: The Franklin Institute Press, 1979.

> A set of presentations from a 1978 conference on teaching thinking skills in all disciplines.

Mason, John, with Leone Burton and Kaye Stacey. *Thinking Mathematically*. London: Addison-Wesley, 1982.

> This is a manual for developing mathematical thinking, a series of mathematical questions posed throughout. It is designed "to show how to make a start on *any* question, how to attack it effectively and how to learn from the experience."

Whimbey, Arthur. "Students Can Learn to be Better Problem Solvers." *Educational Leadership*. Vol. 37, No. 7, April 1980, pp. 560-565.

> The author suggests and describes some innovative techniques for students to interact in a way that facilitates problem solving.

RECOMMENDATIONS FROM THE STUDY

Our site visits and subsequent analysis led to our making some recommendations for further study and action. Following is a list of the major recommendations.

1. We recommend that a study similar in objectives to ours be conducted with an elementary school focus.

2. We recommend that there be concerted efforts to provide training for school mathematics leaders, especially as it is directed toward developing the teacher collegiality deemed so important in our study.

3. We recommend further research and development of methods for enhancing teacher collegiality, especially as it is manifested in talk about instruction, structured observation, and shared planning or preparation.

4. We recommend further research and development of methods for enhancing teachers' classroom communication skills, such as questioning, coaching, communicating high expectations, and creating a classroom environment conducive to risk-taking and exploration.